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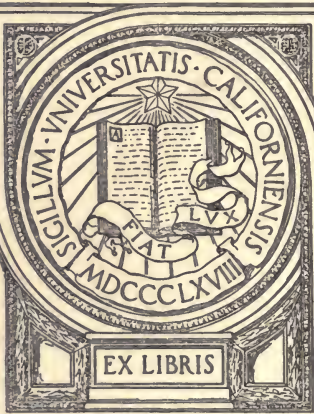


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REVIEW QUESTIONS AND PROBLEMS IN CHEMISTRY

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REVIEW QUESTIONS AND PROBLEMS IN CHEMISTRY

COMPILED BY

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HEADMASTER OF ST. JOHNS SCHOOL, MANLIUS, NEW YORK

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PREFACE

The fact is borne out by the experience of every teacher who has classes to prepare for college examinations, that the contents of the prevailing textbooks fail to furnish adequate scientific material and drill to pass the entrance examinations. The subject is so broad and the theories involved are so complex, that the student often finds himself on the threshold of the examination room completely bewildered by the many facts, theories, laws, and details, and is entirely unable to make a scientific application of his knowledge.

This book has been prepared as a review of the theories and laws of elementary chemistry, and there has been added to each topic a sufficient number of problems to make a thorough application of the student's knowledge. It presumes on the student's part a thorough acquaintance with physical mixtures, laws of densities and specific gravity, laws of heat and electricity, the metric system, and an adequate training in some good textbook in elementary chemistry.

These questions and problems have been taken from the most recent college, College Board, and Regents of the State of New York examinations, and from the latest and most authoritative textbooks, and will be found from the author's experience more than sufficient to prepare a student for the entrance examinations for any college, or for the College Board examinations.

The questions and problems are classified so that a chapter or parts of one may be taken up, in connection with the textbook used in the class, for clinching the principles studied, or the book may be used as a pre-examination review. It is

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not necessary that the student should solve all the problems, but such selection should be made as will assure the instructor that he is adequately prepared.

It must be observed in the use of the book that the student must seek much necessary information from his text, and there should be accessible several good textbooks for handy reference.

Reference to the appendixes will be found helpful in solving many of the problems.

Acknowledgment is hereby made to the authors and publishers of the following textbooks, for the material obtained from their publications: Lee's "Experimental Chemistry," P. Blakiston's Son & Co.; Linebarger's "Chemistry," Rand, McNally & Company; Newell's "Inorganic Chemistry" and Baskerville and Estabrooke's "Problems in Chemistry," D. C. Heath & Co.; Brownlee and Others' "First Principles of Chemistry," Allyn and Bacon; Morgan and Lyman's "Chemistry," The Macmillan Company; McPherson and Henderson's "Elementary Chemistry" and the publications of the College Entrance Examination Board, Ginn and Company; and to the authorities of the various universities, and to the Board of Regents of the State of New York, whose entrance examination questions have been used.

MANLIUS, NEW YORK

M. S. H. UNGER

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- REVIEW QUESTIONS AND PROBLEMS IN CHEMISTRY

CHAPTER I

PHYSICAL DEFINITIONS

1. Define physical change and give two examples.
2. Define matter and energy, density, specific gravity.
3. Define element, mixture, compound, molecule, atom, electron, ion, gas.
4. What are properties? Mention those common to all matter. If we had no senses, would we know anything about the properties of substances?
5. What forms of energy are possessed by a clock? a projectile? a trolley car?
6. When a certain amount of water freezes, does it absorb or give off heat? What difference in heat transfer takes place when water drops in temperature from 2° to 1° , and from 1° to 0° ?
7. Give examples of physical changes which are produced through the agency of heat; of light; of electricity; of chemical changes.
8. Define the difference between a mixture and a compound, and illustrate each.
9. Give examples of gaseous mechanical mixtures and of gaseous chemical compounds. Give similar examples, liquid and solid, and point out the most important difference between compounds and mixtures.

CHAPTER II

CHEMICAL DEFINITIONS

1. How does chemistry differ from physics? What is a chemical change?
2. Define oxidation, reduction, kindling temperature, decay.
3. How does combustion differ from decay and from oxidation?
4. What is a formula? a reaction? an equation? a radical?
5. What is a flame? What causes luminosity? Why is a Bunsen flame nonluminous?
6. Define catalysis, molecule, electrolyte, nascent state, allotropy.
7. Define deliquescence, efflorescence, electrolysis, and illustrate each.
8. Define chemism, vapor density, isomerism, polymerism, absolute temperature.
9. Define hydroxide, alkali, metathetic reaction, solution.
10. Distinguish between crystals and water of crystallization; between colloids and crystalloids; between crystalline and amorphous.
11. Explain and illustrate deflagration, supersaturation, fusion, sublimation.
12. What is meant by bivalent, monatomic, diatomic?
13. State the meaning of distillation, filtrate, titration, standard solution, indicator, neutral reaction.
14. Define the following terms: atom, valence, equivalent, gram molecule, fermentation, precipitation.

15. Give three methods for collecting gases, and the conditions under which each may be advantageously employed.

16. To what classes of changes do the following belong: (*a*) the melting of ice? (*b*) souring of milk? (*c*) explosion of gunpowder? (*d*) corrosion of metals? (*e*) burning of a candle? (*f*) ringing of a bell? (*g*) stretching of rubber? (*h*) boiling of an egg? (*i*) dissolving of sugar? (*j*) decay of meat? (*k*) magnetizing of a nail?

17. What is the property that distinguishes compounds from mixtures? What is an element? What conditions must be taken into account in measuring the volumes of gases? By what instruments are these conditions measured? Give the laws which express the effect of these conditions.

18. Distinguish between chemical and physical properties; between elements, compounds, and mechanical mixtures; between metals and nonmetals; between gases, liquids, and solids; between oxidation and reduction.

19. In the measurement of volumes of gases what do you mean by standard conditions? Should you consider it necessary to make use of such conditions in measuring volumes of liquids or solids? Why?

20. Describe two ways in which well-formed crystals are obtained. How should you distinguish a crystalline from an amorphous body?

21. Explain the object of each of the following processes and how each accomplishes the end in view: (*a*) evaporation of a solution of a solid; (*b*) filtration; (*c*) distillation; (*d*) pulverization before dissolving; (*e*) sublimation.

22. Name two forms of energy that may produce chemical changes, and give an example of a change caused by each.

23. Define each of the following and give an example of each: (*a*) monobasic acid; (*b*) dibasic acid; (*c*) tribasic acid,

and write the name and the formula of a salt formed from each of the acids mentioned.

24. Define spontaneous combustion and explain the phenomenon.

25. Define and illustrate molecular weight, anhydride, deliquescence, antiseptic, precipitate, monad, occlusion.

26. Define and illustrate the following: binary compounds, hydrate, base, dyad, compound radical, metal, negative element.

27. Define chemical change; classify the different kinds of chemical change, and give an example of each.

28. Define basic anhydride, acid anhydride, and give an example of each. What is a dibasic acid?

CHAPTER III

PHYSICAL LAWS AND THEORY

1. State and illustrate the relation that exists between centigrade, Fahrenheit, and absolute-temperature scales.

2. State the formulas for converting temperatures.

3. Explain the meaning of the following statement: "A gas is under standard conditions of temperature and pressure."

4. State (*a*) Boyle's (Mariotte's) Law; (*b*) the Law of Charles.

5. Distinguish between and illustrate (*a*) law, (*b*) theory, (*c*) hypothesis.

6. What is (*a*) occlusion? (*b*) diffusion of gases? (*c*) spectrum analysis?

7. What is the kinetic theory of matter?

8. Define specific gravity or relative density, and show how you would determine the specific gravity of a gas, a liquid, and a solid. If the specific gravity of marble is 2.75, how much in grams would a cubic meter of marble weigh?

9. Explain in terms of the kinetic molecular theory the difference between solids, liquids, and gases.

CHAPTER IV

CHEMICAL LAWS

1. State and illustrate the Law of Definite Proportions.

2. State and illustrate the Law of Multiple Proportions.

3. State the Law of Dulong and Petit. What use is made of it by chemists?

4. State the Periodic Law. What three striking predictions made by Mendeléeff have since been verified?

5. What is the basis of the Mendeléeff classification? What evidence have we that this is a natural system? Discuss the properties of the elements in some natural family in such a way as to show this apparent relation.

6. Give the law for the conservation of matter; of energy.

7. Give Hess's Law of Constant Heat Summation.

8. State the Law of Electrochemical Equivalents; the Law of Equivalent Proportions.

9. State Graham's Law of Diffusion and Transpiration.

10. State the Law of Dalton for a gaseous mixture.

11. What is the Law of Gay-Lussac? Illustrate.

12. State Faraday's Laws of Electrolysis.

13. Name four agencies that may bring about a chemical change, and illustrate.

14. State the Law of Specific Heats. Illustrate its use by an example.

15. What are Berthollet's Laws?

16. What distinction would you make between a law and a theory? Give an illustration of each and tell why it is thus classified.

17. The formulas of the five oxids of nitrogen are N_2O , NO , N_2O_3 , N_2O_4 , and N_2O_5 . What simple ratio exists between the varying weights of oxygen?

18. State and illustrate Ampère's Law. Mention a method of finding the molecular weight of a given compound when its atomic weights are not known.

19. State what is meant by saying that the vapor density of a gas is 44.

20. State Boyle's Law and Charles's Law. A certain quantity of a gas occupies 1 l. at $0^\circ C.$ and 760 mm. Calculate its volume at $20^\circ C.$ and 750 mm.

21. State Avogadro's Law; also the Law of Multiple Proportions. What volume of carbon dioxide would be formed if 1 l. of acetylene (C_2H_2) burned in oxygen with the formation of CO_2 and H_2O ?

22. What is the law governing the combination of gases by volume? Give some examples illustrating the law. What is the hypothesis advanced to explain it? Show how this hypothesis gives rise to a method of expressing the weights of molecules.

23. What evidence have we that matter is indestructible? If we cannot create matter, how are we to account for the fact that the products of combustion of a candle weigh more than the original candle?

24. Give and illustrate two laws that lie at the foundation of chemical knowledge. What law gives the basis for calculating molecular weight?

25. Give the characteristics of a chemical change, and two important laws governing chemical change.

CHAPTER V

CHEMICAL THEORY

1. State the principle of Dalton's Atomic Theory.

2. State the theory of Avogadro, and illustrate it by the union of oxygen and hydrogen to form water, and of hydrogen and chlorine to form hydrochloric acid.

3. Explain the theory of electrolytic dissociation.

4. Show how Avogadro's theory is used for determining molecular and atomic weights.

5. Employ the Avogadro theory in calculating the atomic weight of oxygen from the following data: carbonic acid gas, steam, laughing gas, and sulphurous anhydride contain, in the order named, 72.73, 88.89, 36.364, and 50.00 per cent by weight of oxygen; their densities are, in the same order, 22, 9, 22, and 32.

6. Tell what substance and how much of it, in terms of the atomic-molecular theory, is represented by each of the following symbols and formulas: HCl, Ba, Fe, P_2O_5 , O_2 , O_3 , KOH, $Zn(NO_3)_2$, I, SiO_2 .

7. State Gay-Lussac's Law of the combining volumes of gases and show how it led to Avogadro's hypothesis.

8. What is meant by (*a*) the molecular weight of a gas, and (*b*) the density of a gas? What relation exists between the molecular weights and the densities of gases? Illustrate.

9. What evidence have we that one element can change into another, and what explanation is offered?

10. State the Law of (a) Definite Proportions; (b) Multiple Proportions. Show how the atomic hypothesis is developed from these laws.

11. State Avogadro's hypothesis. Show how the molecular weight of a given substance that can be volatilized may be found by this hypothesis.

CHAPTER VI

CHEMICAL DIVISION

1. Define an acid, a base, and a salt, and give an example of each.

2. Give the names of the following acids, and of the potassium salt of each: HCl, HClO, HClO₄, HClO₃, HNO₂, HNO₃, H₂SO₄, HBr, H₃AsO₄, HF.

3. What is a formula, a chemical equation, a reaction, a graphic equation? Illustrate.

4. Illustrate an endothermic and an exothermic reaction.

5. Illustrate and explain the difference between analytic, synthetic, and metathetic reaction.

6. Define and illustrate neutralization, normal salt, acid salt, basic salt, an anhydride.

7. Give an example of a dibasic acid. Of H₂SO₄ acting (a) as an acid; (b) as a drying agent; (c) as a strong acid displacing a weaker one (equation).

8. Classify as (a) bases; (b) acids; (c) salts: NaNO₃, NH₄Cl, HClO, NH₄OH, BaSO₄, Ca(NO₃)₂, HClO₄, Sr(OH)₂, HNO₂, Fe(OH)₃.

9. Write the formulas for the following compounds: barium perchlorate, ammonium sulphate, strontium nitrate, calcium sulphate, ferric sulphate, sodium perchlorate, calcium hypochlorite, barium hydroxide, strontium oxide, barium nitrate.

10. What is a primary salt? Write the formulas for primary sodium sulphate, primary calcium phosphate, secondary sodium carbonate.

11. How may hydrochloric acid be prepared? State the properties of this acid.

12. Write the formulas for limestone, secondary sodium phosphate, cupric sulphate, ammonia, aluminum phosphate, mercurous chloride, barium nitrate, acetylene, gypsum, marsh gas.

13. Write the formulas for sodium carbonate, lead sulphate, silica, arsine, arsenic trioxide, ammonium sulphide, normal calcium phosphate.

14. Write the formulas for potassium chloride, sodium carbonate, phosphoric acid, sodium cyanide, ferric oxide, ferrous sulphide, ferric chloride, aluminum sulphate, cuprous oxide, manganese dioxide.

15. Write the equation for the reactions that occur between

1. Potassium hydroxide and sulphuric acid.
2. Calcium hydroxide and ammonium sulphate.
3. Ferric chloride and ammonium hydroxide.
4. Sodium hydroxide and phosphoric acid.
5. Ammonium nitrate with heat.

16. Describe in detail the manufacture of H_2SO_4 .

17. Write the equations for the reactions between

1. Calcium carbonate and hydrochloric acid.
2. Potassium nitrate and sulphuric acid.

3. Copper and water vapor (heated).
4. Aluminum sulphate and ammonium hydroxide.
5. Calcium carbide and water.

18. Write the equations for the reactions :

1. Silver nitrate and sodium chloride.
2. Aluminum sulphate and potassium hydroxide.
3. Ammonium sulphate and slaked lime.
4. Sodium chloride, manganese dioxide, and sulphuric acid.
5. Chlorine and potassium bromide.
6. Steam and incandescent coke.
7. Calcium hydroxide and carbon dioxide.
8. Methane and oxygen (ignited).

19. What is meant by the terms "saturated solution" and "supersaturated solution"? Under what conditions will crystalline sodium sulphate effloresce?

20. For what do the following symbols and formulas stand: SO_2 , C, CH_4 , FeO, Fe_2O_3 , CO_2 , CaCO_3 , Hg, I_2 , H_3PO_4 , NaOH, NH_4 , NH_3 , Ag, Al, O_3 , S_6 , AsO_3 , SnO_2 , and $\text{Pb}(\text{OH})_2$.

21. Define basic anhydride and acid anhydride, and give an example of each.

22. Classify the following substances as (a) acids, (b) bases, or (c) salts, and give the name of each: H_2SO_4 , KCl, KHSO_4 , NH_4OCl , NaOH, CaF_2 , HI, $\text{Ca}(\text{ClO}_3)_2$, NaNO_3 .

23. To what extent does the composition of a pure chemical compound vary? Take as an example pure sodium chloride from various sources, and mention other examples if possible.

24. Give chemical names and molecular formulas for the following substances: borax, Epsom salts, Glauber salts, white vitriol, green vitriol, blue vitriol, iron pyrites, hematite, magnetite, potash, galena, alum, gypsum, cryolite.

25. Complete and balance :

1. $\text{Al}_2(\text{SO}_4)_3 + \text{KOH} =$
2. $\text{Al}(\text{OH})_3 + \text{KOH} =$
3. $\text{Al}(\text{OH})_3 + \text{HCl} =$
4. $\text{AgNO}_3 + \text{KBr} =$
5. $\text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} =$

26. Complete the following, using symbols and formulas :

1. Ammonium hydroxide + hydrochloric acid =
2. Ammonia + hydrochloric acid =
3. Sodium chloride + silver nitrate =
4. Ferrous sulphide + sulphuric acid =
5. Lead nitrate + hydrogen sulphide =
6. Manganese dioxide + hydrochloric acid =
7. Calcium carbide + water =
8. Arsenic trioxide + nascent hydrogen =
9. Sodium carbonate + nitric acid =
10. Calcium hydroxide + carbon dioxide =

27. Explain the terms "ion" and "ionization." What classes of substances are ionized when dissolved in water? By what term are all such substances designated? Define acid and base in terms of the theory of electrolytic dissociation.

28. Explain by the ion theory the action of hydrochloric acid on potassium hydroxide in dilute solution.

29. Classify the given compounds under the following headings: (a) acids; (b) bases; (c) normal salts; (d) acid salts; (e) anhydrides; (f) oxides: CO_2 , NaHSO_4 , CaCl_2 , PbO , H_3PO_4 , $\text{Ca}(\text{OH})_2$, Na_2SO_3 , MnO_2 , SO_2 , NaOCl .

30. Write the chemical name of each of the following: white lead, blue vitriol, calomel, gypsum, saltpeter, caustic potash, copperas.

31. Distinguish in meaning between the following suffixes when used in names of chemical compounds: (a) *ous* and *ic*; (b) *ite* and *ate*. (c) When are *hypo* and *per* prefixed?

32. Define each: (a) monobasic acid; (b) dibasic acid; (c) tribasic acid. Write the name and the formula of a salt formed from each of the acids mentioned.

33. Find the percentage composition of HNO_3 . Describe a method of preparing nitric acid, writing the reaction. Mention its uses.

34. What substances do you employ in the laboratory preparation of hydrochloric acid? Why was each substance selected? Give the reason for the method used.

35. Write the chemical name of each of the following: H_2SO_3 , NaHCO_3 , H_2S , $\text{Fe}(\text{SO}_4)_3$, P_2O_5 .

36. Complete the following equations, using formulas:

1. Sodium hydroxide + carbon dioxide =
2. Lead nitrate + hydrogen sulphide =
3. Calcium hydroxide + nitric acid =
4. Phosphorus + oxygen =
5. Sodium carbonate + calcium chloride =
6. Hydrogen + (hot) copper oxide =

State which of these compounds are (a) acids; (b) bases; (c) salts; (d) anhydrides. Which of the equations are examples of (e) oxidation? (f) reduction? (g) double decomposition? (h) neutralization?

37. State how you could distinguish between

1. Concentrated and dilute sulphuric acid.
2. Sodium chloride and sodium sulphate.
3. Copper sulphate and potassium sulphate.
4. Platinum and magnesium.
5. Pulverized charcoal and manganese dioxide.
6. Hydrogen and carbon monoxide.

38. What determines whether a gas should be collected (a) over water? (b) by downward displacement of air? (c) by upward displacement of air? State the method used in collecting ammonia, hydrogen sulphide, carbon dioxide, nitric oxide.

39. Describe two ways in which well-formed crystals are obtained. How should you distinguish a crystalline from an amorphous body?

40. Explain each of the following processes, and state how each accomplishes the end in view: (a) evaporation of a solution of a solid; (b) filtration; (c) distillation; (d) pulverization before dissolving; (e) sublimation.

41. Describe experiments by which you could determine whether

1. An alloy contained copper or silver.
2. A washing powder contained sodium carbonate.
3. A sample of potassium chlorate contained potassium chloride.
4. A sample of material contained sand or lime.
5. A gas was nitrogen or carbon dioxide.

42. Distinguish between organic and inorganic chemistry; between metals and nonmetals.

43. Name the following acids and write the formula and name the sodium salt for each:

HI	HNO ₃	H ₃ PO ₂	H ₂ SO ₄
HIO ₃	HNO ₂	H ₃ PO ₃	H ₂ SO ₃
HIO ₄	HNO	H ₃ PO ₄	H ₂ S ₂ O ₈

44. When perfectly dry sulphuric acid is treated with perfectly dry sodium hydroxide, no chemical action takes place. Why?

45. What is a radical? Give six examples.

46. What are the main points of difference between metals and nonmetals in the free state? What chemical property differentiates them as a rule? Name some elements which have properties of both.

47. Define acid and base. What is the important theoretical conception concerning solutions? What is the meaning of the terms "weak" and "strong" as applied to these substances? Define hydrolysis.

48. State the differences between the solutions obtained by passing dry ammonia gas into water and sulphur dioxide into water. What is the result if each solution is evaporated separately? Explain. What is obtained when the solutions are mixed and evaporated to dryness?

49. What weight of $\text{Ca}(\text{OH})_2$ can be prepared from 1 kg. of quick lime, and what weight of HCl will be neutralized by the $\text{Ca}(\text{OH})_2$ thus made?

CHAPTER VII

ELECTROLYTIC DISSOCIATION

1. Describe in full what happens when a solution of sodium sulphate is electrolyzed.

2. Describe in detail what takes place when an electric current is passed through water that has been acidulated with sulphuric acid.

3. Explain what takes place when a solution of copper sulphate is electrolyzed with a copper cathode and a copper anode. What commercial use is made of this process? If both terminals were platinum.

4. Explain the terms "ion" and "ionization." What classes of substances are ionized when dissolved in water?

By what term are all such substances designated? Define acid and base in terms of the theory of electrolytic dissociation.

5. Explain by the ion theory the action of hydrochloric acid on potassium hydroxide in dilute solution.

6. How would you determine whether a given solution is an electrolyte?

7. To bring about a reaction between dry substances, why is it necessary to place them in water?

8. Distinguish carefully between an ion of sodium and an atom of sodium.

9. Explain the fact that sulphuric acid is less active than nitric acid.

10. Give the conditions under which a reaction goes on to completion.

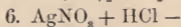
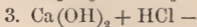
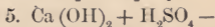
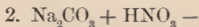
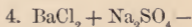
11. If a certain current of electricity deposits 31.7 g. of copper, (a) how much silver would it deposit? (b) how much zinc?

12. From the standpoint of the theory of electrolytic dissociation (a) write the simple equation for a dilute solution of copper sulphate; this is a blue solution. (b) In the same manner write one for sodium sulphate; this is a colorless solution. How would you account for the color in the first case?

13. Why will vegetables cook faster when boiled in strong salt water than when boiled in pure water?

14. Write equations showing how the following substances ionize: HCl ; HNO_3 ; NaOH ; $\text{Ca}(\text{OH})_2$; ZnSO_4 ; $\text{Fe}(\text{NO}_3)_2$.

15. Write ionic equations for the interactions of the following substances. Do the reactions run to equilibrium or to completion? Why in each case?



16. Why do less volatile acids decompose the salts of more volatile acids and liberate the latter?

17. Why does liquid chlorine possess no acid properties? Would you expect it to conduct an electric current?

18. Salt dissolved in pure water conducts electricity; sugar does not. Explain according to modern views.

19. Describe the changes undergone by a solution of sodium sulphate (colored with litmus) when subjected to the action of a current of electricity. How may the direction of the current be determined?

20. Define the term "electrolysis." Explain briefly by means of a diagram what takes place when an electric current is passed through a solution of common salt.

21. Define dissociation. Describe a laboratory experiment to illustrate the dissociation of a chemical compound by the aid of electricity.

22. What important difference is there between the behavior of table salt and that of sugar when dissolved in water? How may the peculiar behavior of salt be shown? Name some of the substances which behave in this manner.

23. Define an ion and an electrolyte.

24. A current deposits 1 g. of sodium; find the weight of Ni deposited by the same current.

25. How many grams of Ag will be deposited from a solution of AgNO_3 by a current of 2 amperes in 30 minutes?

26. How much would a metal plate increase in weight if it were nickel-plated by a current of 0.5 ampere running 5 hours?

27. If the specific resistance of Ca is 0.000001629, what is the resistance of a wire 200 m. long having a cross section of 2 mm.²?

28. Gladstone and Hibbert on passing the same electric current through solutions of zinc and silver obtained quantities of the metals in the ratio of (Zn) 1 : (Ag) 3.298. If the equivalent of silver is 197.94, what is that of zinc?

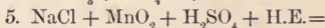
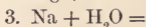
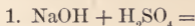
29. When sulphuretted hydrogen is added to a solution of ZnSO_4 , why is the zinc not completely precipitated as sulphide? How may the precipitation be made approximately complete? Explain by means of the hypothesis of electrolytic dissociation and the law of mass action.

CHAPTER VIII

VALENCY

1. For what do the following symbols and formulas stand: SO_2 , C, CH_4 , Fe_2O_3 , CO_2 , CaCO_3 , Hg, I_2 , H_3PO_4 , NaOH, (OH), (NH_4) , NH_3 , Ag, Al, O_3 , S_6 , As_2O_3 , SnO_2 , and $\text{Pb}(\text{OH})_2$?

2. Complete and balance :



NOTE. H.E. stands for heat energy.

3. What is meant by saying that a chemical equation "balances"? Why is it incorrect if it does not "balance"?

4. What is valence? What is the valence of iron in FeO_3 , and of silicon in SiH_4 ? What is meant by saying that an element occurs in different allotropic forms?

5. Define valence. State and illustrate the theory of valence.

6. If 1 l. of bromine vapor weighs 7.2 g. and if 1 g. of H combines with 80 g. of bromine, what is the valency of bromine?

7. The valency of the following elements is indicated by the number of accents: Na', K', Ca'', Al'''. What are the formulas of the chlorides and the oxides of each of the elements if Cl is univalent and O is bivalent?

8. How many liters of hydrogen gas can be obtained from 4 l. of HCl acid gas?

CHAPTER IX

PERIODIC LAW AND THE CLASSIFICATION OF THE ELEMENTS

1. State the Periodic Law. What three striking predictions made by Mendeléeff have since been verified?

2. Discuss the periodic classification of the elements. What evidence have we that this is a natural system? Discuss the properties of the elements in some natural family in such a way as to show their apparent relation.

3. Name the important services the law (periodic) has rendered to chemistry.

4. What property of an element determines its position in the periodic arrangement of the elements?

5. Arrange the following elements in groups according to some natural classification: aluminum, barium, iron, phosphorus, silicon, sodium, sulphur.

6. What is the difference between the Periodic Law and the Periodic System?

7. State the characteristics of the alkali group; of the halogen group; of the carbon group; of the argon group.

8. If lead is an element and radium is an element, what is the most significant difference between them?

9. What reasons are there for thinking that there may be only one form of matter?

10. Suppose that an element were discovered that filled the blank in Group VI, Period 9, Family B (see Appendix), what properties would it have?

CHAPTER X

HYDROGEN AND WATER

1. (*a*) Give two physical and two chemical properties of H. (*b*) Name two metals which displace H from dilute HCl, and two that do not.

2. State Gay-Lussac's Law of Volumes and illustrate it by a consideration of the union of H and Cl. Show by Avogadro's theory and the foregoing law that a molecule of H₂ contains at least two atoms.

3. What volume of H measured under standard conditions is required to reduce 11.94 g. of CuO? What is the weight and what the volume of the water (liquid) formed?

4. $2\text{H}_2 + \text{O}_2 = 2\text{H}_2\text{O}$. What does this equation signify in regard to (*a*) molecules, (*b*) the weights, and (*c*) the gas volumes of the reacting substances and of the product?

5. How many grams of the metal Zn are necessary for the production, by the action of hydrochloric acid on the metal, of 90 l. of H measured under standard conditions?

6. 30 cc. of H is mixed with 40 cc. of air that contains 20 per cent of O, and the mixture is ignited. What gases remain after explosion and what is the volume of each?

7. When H and O unite, state the relation of the volume of steam produced to the volumes of H and O used. State the law thus illustrated.

8. A tube containing copper oxide (CuO) weighs with its contents 63 g. This tube is heated to redness and H passed through it. When cooled the tube with its contents is again weighed, and the weight is now found to be 60 g. What volume of H measured under standard conditions has united with the O of the copper oxide?

9. How may water be freed (a) from insoluble solid matter? (b) dissolved salts? (c) dissolved air?

10. Give the formulas of a compound of H and S and of two oxides of sulphur. Show by equations how each of these oxides of S would react with a water solution of NaOH .

11. Give the volume relations between the gases in the following reactions: hydrogen and chlorine combining to form hydrochloric acid; hydrogen and oxygen to form steam; hydrogen and nitrogen to form ammonia. If a million molecules of H took part in each reaction, how many molecules of each product would be formed?

12. If to 36 g. of water at ordinary temperature we add metallic sodium until no further reaction takes place, what weight of H will be set free? What volume will it occupy at 18° and 740 mm.? What proportions of the H originally contained in the water will it constitute? What weight of Na will suffice? How many gram-atoms of Na will this be? How many gram-molecular volumes will the H occupy?

13. Show how the composition of water may be determined by weight and by volume.

14. Distinguish between hard and soft waters. How are hard waters softened? How do we obtain pure water?

How does pure water at ordinary room temperature behave when heated to 100°C . or cooled to 0°C .?

15. Describe the process by which water may be decomposed by electrolysis, touching on apparatus generally used and method of collecting the resulting gases. Name the gases and give the test for each.

16. What is meant by a solution of a substance? Describe an experiment illustrating (a) saturated solution; (b) a supersaturated solution.

17. Distinguish in composition between water of permanent hardness and that of temporary hardness, and state how each may be softened.

18. Dumas and Stas obtained the result of nineteen determinations of the gravimetric composition of water to be an average of 840.161 g. of O formed from 945.439 g. of water. Calculate the ratio of combination.

19. If crystallized calcium sulphate contains about 18 per cent of water, what volume of steam at 200°C . and 755 mm. is given off by heating 100 g. of the solid until all the water of crystallization is expelled?

20. Calculate the volume of 1 g. of H under standard conditions.

21. Iron and tin ores usually are oxides. In obtaining the metals what kind of reactions are used?

22. What changes would take place in nature if water did not expand (a) when cooled below 4°C .? (b) when it freezes?

23. The gas density of water vapor is about 9. Calculate the volume occupied by 1 g. of water when in the form of steam at 100° . When the steam is doubled in volume, to what temperature would it have to be heated?

24. How could you determine the total amount of solid material contained in a sample of water?

25. How may it be ascertained by experiment that water contains the elements hydrogen and oxygen and these two elements only?

26. What weight of H will be required for the complete reduction of 10 g. of CuO? At 740 mm. and 15° C. what will be the volume of the H?

27. What is meant by "water of crystallization," and what relation does it bear to the terms "efflorescence" and "deliquescence"?

28. Describe three methods of obtaining hydrogen by the decomposition of water.

29. Describe the essential features of the "mechanical method" of water filtration.

30. How may impure water be rendered fit for drinking purposes?

31. How would you prove that the composition of water is expressed by the formula H_2O ?

32. A liter of H weighs 0.0899 g. A liter of oxygen weighs 1.429 g. Explain the significance of the term "atomic weight," and explain the calculation of the atomic weight of O from the above data.

33. Describe an experiment illustrating the solubility of ammonia in water.

34. One volume of oxygen at 80° C. will go to form how many volumes of steam under the same conditions? How will the number of molecules of each compare? What inference can be drawn from the last answer as to the character of the O molecule? How do we account for the increase in the density when O is converted into ozone?

35. To what constituent do acids owe their characteristic properties? Does this substance impart these properties to all its compounds? What is the theory advanced

to explain the facts embraced in your answer? How do we explain the fact that some acids are stronger than others? Name some other facts which the above-mentioned theory explains.

36. What weight of Zn would be required for the production of sufficient H at 21°C . and 745 mm. pressure to fill a balloon with a capacity of 100 cc.?

37. Make a sketch of an apparatus employed for the electrolysis of water; explain the process and state the significance of the result.

38. State all that takes place when steam is passed over heated iron. How may the gaseous product of the reaction be identified? Make a sketch of the apparatus which might be used to carry out this experiment. Making use of the solid product, outline an experiment to illustrate the production of water.

39. How much sodium by its action upon water is required to furnish 76 l. of H at 100°C . and 746 mm.?

40. How may it be shown experimentally that ammonia consists of H and N?

41. What are hydrazine and hydrazoic acid? Discuss their properties.

42. 32.3 cc. of H at 18°C . and 744 mm. are introduced into a eudiometer, 56.8 cc. of O at 20°C . and 745 mm. added. Which gas and how much of it at 21°C . and 745 mm. will be left after the explosion, if the tension of the aqueous vapor produced be taken into account?

43. Show how the composition of water and of hydrogen peroxide illustrate the Law of Multiple Proportions.

44. Would you use Zn or Fe for making H to fill a large balloon? Why? Would H make a good illuminating gas?

45. Is water an oxide? an anhydride?

46. The density of Cl is nearly thirty-six times that of H. Compare its rate of diffusion with that of H.

47. If the density of ice is .92, what volume will a liter of water at 4° C. occupy when frozen?

48. Give three reasons for considering that water is not an elementary substance. Define the terms "element" and "compound."

49. How many grams of H can be obtained by treating 30 g. of Zn with sulphuric acid, and what will be the volume at 20° C. and 760 mm.?

CHAPTER XI

NITROGEN GROUP AND AIR

1. How can ammonia be made from ammonium chloride? Write equations to show how ammonium hydroxide reacts with nitric acid and aluminum chloride.

2. Calculate the volume that 10 l. of air at 25° C. would occupy at 0° C.

3. Give the name and formula for the common nitrogen acid. From what is it usually made and how? Illustrate the important chemical properties of the acid by equations for its reactions with both zinc and zinc oxide.

4. Explain the fact that when strong nitric acid acts on copper, red fumes are evolved. Illustrate your explanation by equations.

5. Give the formulas for two common oxides of phosphorus; also for two common oxides of arsenic. Write the equations for reactions showing the formation of two salts containing phosphorus, and of two salts containing arsenic.

6. Show by equations the different effects of concentrated nitric acid on copper, cuprous oxide, and cupric oxide.

7. How do arsenic and antimony differ from the true metals?

8. Give the reaction equations for the preparation of the following substances: ammonia, nitric acid, nitric oxide, nitrous oxide, phosphorus.

9. What volume of ammonia gas, at a temperature of 20° C. and a pressure of 740 mm. of mercury, can be obtained from 214 g. of sal ammoniac, and how should one proceed to prepare it?

10. Name and describe the elements of the nitrogen family; mention the group to which they belong and state its general characteristics.

11. Give the sources, preparation, properties, and uses of nitric acid.

12. Write the formulas of the potassium and ammonium salts of sulphuric and nitric acids; of nitrogen peroxide.

13. Why is it impossible to write a chemical formula of air? Why is a mixture of air with illuminating gas explosive?

14. Write the equations for (a) the neutralization of potassium hydroxide and nitric acid; (b) preparation of nitrogen from sodium nitrite and ammonium chloride.

15. Give, with equation, a method of preparation of ammonia and state the properties of the substance.

16. Write the formula for primary ammonium phosphate, secondary potassium phosphate, ammonium sulphate, calcium phosphate, sodium nitrate.

17. Write the names and formulas of the five oxides of nitrogen. Give a brief statement of the important law illustrated by these compounds.

18. What are the constituents of the atmosphere: (a) permanent? (b) variable?

19. What weight of nitrous oxide will be formed when 80 g. of ammonium nitrate is decomposed by heat? What will be the volume of this nitrous oxide at 745 mm. pressure and a temperature of 18°C .?

20. Give the structural formulas of NH_4Cl , NH_4OH , and $(\text{NH}_4)_2\text{SO}_4$.

21. The formula of phosphoric acid is H_3PO_4 . What is the formula of primary sodium phosphate? secondary ammonium phosphate? normal calcium phosphate? secondary calcium phosphate?

22. The specific gravity of ammonia compared to H is 8.5. What is its molecular weight? Explain the steps by which this result is reached.

23. Discuss the preparation of P as to equation and method and describe its allotropic forms.

24. How is ammonia used in refrigeration? Describe the methods of preparation and the properties of liquid air.

25. From what material and by what process may white phosphorus be made? What are its properties and for what is it used? How may it be converted into red phosphorus?

26. What is white arsenic? How may arsenic be detected in a case of suspected poisoning?

27. Give two reasons for the belief that the nitrogen and the oxygen in the atmosphere are mixed and not combined.

28. In what great industry is calcium phosphate (normal) employed? To what treatment must it be subjected? How may free phosphorus be prepared? What is its usual source?

29. Give the sources, method of preparation, and properties of the element nitrogen.

30. Give the equation for the reaction that takes place when laughing gas is prepared. Make a sketch of the apparatus used.

31. Give formulas and names of some compounds of phosphorus, arsenic, and nitrogen, which are analogous in their formulas and chemical behavior.

32. Which of the constituents of the atmosphere are essential to animal life and which to plant life? What is returned to the atmosphere by animals and what by plants? Give two reasons to show that these constituents of the atmosphere are not in chemical combination.

33. What is the commercial source of ammonia? How is it prepared (equation) and how may it be shown (*a*) that it has the character of a base, (*b*) is lighter than air, (*c*) and is readily soluble in water?

34. When N is prepared from the atmosphere what other element does the gas contain? Name two different ways in which the salts of nitric acid may be prepared.

35. Compare the properties of the two common modifications of phosphorus. What is the formula of the product of the combination of phosphorus in oxygen, and what name is given to this compound which indicates its chemical behavior?

36. Name two metals which are not readily acted upon by the atmosphere. For what purposes does this property of these metals render them particularly serviceable?

37. Name the compounds commonly used as the sources of nitrogen, phosphorus, and potassium in commercial fertilizer. How is the nitrogen of the air made available for plant food?

38. How could you show the presence of four substances in the air?

39. Write the graphic formula of arsenic trioxide. Describe its preparation and mention its important properties and uses.

40. Describe a method of preparing hydrogen arsenide. Give equation. State the ordinary use of hydrogen arsenide.

41. Explain the instability of nitrogen compounds. Describe an experiment illustrating this instability.

42. Describe a process of extracting the metal arsenic from one of its ores. Mention the physical and chemical properties of arsenic.

43. Describe in detail Marsh's test for arsenic and write the reaction.

44. Two compounds have the following composition: (a) phosphorus 56.36 per cent, oxygen 43.64 per cent; (b) phosphorus 43.65 per cent, oxygen 56.35 per cent. Show whether or not the Law of Multiple Proportion holds.

45. Give the name and compound formed (a) when phosphorus burns in air; (b) when the product is treated with water and the solution boiled. Write the equations for both reactions.

46. Mention four gaseous components of the atmosphere and tell briefly how you would demonstrate their presence.

47. Describe the preparation of ammonium chloride as a by-product in the manufacture of illuminating gas from coal. Give the important uses of ammonium chloride.

48. Give the composition of ordinary gunpowder. Explain the expansive force of ignited gunpowder and write the reaction that takes place.

49. Give at least two reasons for the belief that the oxygen and nitrogen of the atmosphere are not in chemical combination.

50. What chemical changes are produced by the action of lightning in the air? Does atmospheric N differ from that obtained from a compound?

51. Name the members of the nitrogen family, tabulate their resemblances and analogous compounds, and show how that relation illustrates the basis of the natural classification of the elements.

52. When ammonia and air are heated and passed over the catalytic agent (spongy platinum) nitric acid is formed. What does this prove as to the composition of nitric acid?

53. What happens to nitric acid when passed through a red-hot tube? What is the effect of heat upon (a) potassium nitrate? (b) lead nitrate? (c) ammonium nitrate?

CHAPTER XII

OXYGEN-SULPHUR GROUP

1. What volume of oxygen, measured under standard conditions, will be evolved when 198 g. of mercuric oxide are decomposed by heating? What will be the volume of the oxygen at 770 mm. pressure and 27° C.?

2. When 2 g. of a certain substance were heated, all the oxygen which the substance contained was given off and the residue weighing 1.97 g. was left. Calculate the percentage of oxygen in the substance.

3. Describe briefly experiments in the laboratory to illustrate the effect of heat on sulphur (the air excluded).

4. State briefly how you could distinguish between

1. Concentrated and dilute sulphuric acid.
2. Sodium chloride and sodium sulphate.
3. Copper sulphate and potassium sulphate.

5. State what substances you would use to prepare: (a) SO_2 ; (b) H_2S ; (c) CO ; (d) CO_2 .

6. Describe how you would prepare SO_2 in the laboratory. Give its physical and chemical properties. How may it be converted into H_2SO_4 ? How could you distinguish a solution of sulphurous acid from sulphuric acid?

7. Name some of the chemical results which might be expected if the atmosphere were composed entirely of O.

8. How is hydrogen sulphide made? Mention the important physical properties; the chemical.

9. What is formed when a solution of sodium hydroxide is saturated with hydrogen sulphide?

10. What is the principal product when sulphur burns in the air? Give two physical properties of the compound and show by equations how it reacts with water and with two different oxidizing solutions.

11. Write the equations showing the reactions of dilute sulphuric acid with the following substances: (a) sodium sulphide; (b) potassium carbonate; (c) ammonium hydroxide; (d) cupric oxide; (e) aluminum hydroxide; (f) lead nitrate; (g) barium chloride; (h) zinc.

12. Give the formulas for the common oxides of phosphorus, calcium, copper, and silicon. Which of these oxides unite readily with water? Give the names and the formulas for the compounds so formed.

13. Calculate the volume of carbon dioxide at 20°C . and 750 mm. pressure that would be produced by burning 200 g. in oxygen.

14. Write the formulas, and indicate whether basic or acidic, of the oxides of the following elements: aluminum, barium, iron, phosphorus, silicon, sodium, sulphur.

15. Show that the preparation of sulphur dioxide from a sulphite is similar in principle to the preparation of hydrogen sulphide.

16. Calculate the percentage composition of sulphurous anhydride and sulphuric anhydride. Show how these two substances are in harmony with the Law of Multiple Proportions.

17. How many pounds of sulphur would be necessary in the preparation of 100 lb. of 90 per cent sulphuric acid?

18. Write the names and formulas of the oxides and oxygen acids of selenium and tellurium.

19. What weight of potassium chlorate is necessary to prepare 200 l. of oxygen at 20° C. and 750 mm., and what is its productive cost at .50 ct. per kilogram?

20. How does a mixture of potassium chlorate and manganese dioxide act when heated? What gas is evolved? Is there interaction, and if not, what is such a process called?

21. Distinguish between combustion, decay, oxidation, and putrefaction.

22. Explain spontaneous combustion and give examples.

23. Compare the manufacture of sulphur with that of charcoal.

24. Coal often contains iron pyrites. What sulphur compounds do you think would be found in illuminating gas made from such coal?

25. How would you distinguish between a sulphide, a sulphite, and a sulphate?

26. How much, both by weight and by volume, is required to burn 100 g. of S containing 12 per cent of incombustible impurities?

27. Describe the occurrence of sulphur in nature and state the uses to which it is put.

28. State three ways of preparing SO_2 and tell how it is converted into SO_3 .

29. With the aid of Avogadro's hypothesis calculate the volume of oxygen that will be required for the complete combustion of 10 l. of the following gases: (a) acetylene; (b) methane; (c) ethane, C_2H_6 ; (d) ethylene, C_2H_4 ; (e) CO. What volume of CO_2 will be formed in each case?

30. How does ozone differ from oxygen? How may ozone be prepared? What are its properties and uses? Give in full the properties of oxygen.

31. Give the properties of H_2SO_4 and describe its preparation by the "contact" process.

32. Give three methods for the preparation of oxygen and explain what relation it bears to respiration and combustion.

33. How much H_2SO_4 and zinc would be needed to fill 1100 balloons, each of a capacity of 2000 cc., with hydrogen at a pressure of 1000 mm. of mercury?

34. Describe (with sketches) two experiments by means of which it may be shown that under certain conditions a gas ordinarily spoken of as a supporter of combustion may become a combustible.

35. Define oxidation and reduction and give two examples of each. Describe three experiments to illustrate the difference between the properties of oxygen and atmospheric air.

36. The weight of a liter of O under standard conditions is 1.429 g. What volume will 25 kg. of O occupy at a temperature of 18°C . and a pressure of 740 mm.?

37. What volume of a solution of H_2SO_4 containing 196 g. of the acid per liter will be required for the exact neutralization of 100 cc. of a solution of NaOH containing 40 g. to the liter?

38. Give all possible uses of H_2SO_4 .

39. Write equations showing the result of adding H_2SO_4 to (a) iron; (b) quicklime; (c) a solution of barium chloride. What is the chemical change which takes place when H_2SO_4 is added to sugar?

40. Under what conditions is native sulphur usually found? Name two classes of sulphur compounds which occur in nature.

41. How may SO_2 be prepared by (a) an oxidizing process? (b) by reduction?

42. How many grams of copper sulphide can be formed by burning 2 g. of copper in sulphur vapor?

43. Explain the chemical difference in the bleaching action of SO_2 and Cl.

44. Describe (a) the principal sources of sulphur in nature. (b) State one method of preparation. (c) Mention allotropic forms.

45. Explain why the gaseous product produced by the action of H_2SO_4 with copper differs from that usually produced by the action of an acid with a metal.

46. Give the proportions of O in normal air by weight and by volume and describe a laboratory experiment to show how each of these proportions are determined.

47. Describe an experiment showing the value of H_2S as a reducing agent. State the property of H_2S to which its value as a reducing agent is due.

48. Berzelius converted 10.000 g. of lead into 14.642 g. of lead sulphate (PbSO_4). The atomic weights of lead and of oxygen are 206.91 and 16.00. Calculate the atomic weights of sulphur.

49. Is the equation for the preparation of hydrosulphuric acid a reversible one? As ordinarily carried out, does it complete itself? Does dry hydrosulphuric acid react with litmus?

50. In what respects is sulphurous acid like carbonic acid ?

51. How does a mixture of chlorate and manganese dioxide act when heated? Calculate the volume under standard conditions and also the weight of the gas produced if 245 g. of chlorate are used.

52. Describe a method of preparing oxygen, describe its properties, and relate the history of its discovery.

53. Describe the lead-chamber process for the manufacture of H_2SO_4 .

54. Define combustion and kindling temperature. Give an account of the discovery of oxygen and of the effect which the study of its properties had upon the development of the science of chemistry.

CHAPTER XIII

CARBON, SILICON, TIN, LEAD GROUP

1. Compare the composition, manner of formation, and properties of the oxides of carbon, silicon, tin, and lead.

2. How do you account for a weak acid such as H_2CO_3 being able to decompose such stable compounds as the silicates, as illustrated by the weathering of rocks ?

3. A certain ore has 90 per cent galena. How much pure lead can be obtained from a ton of the ore ?

4. If white lead were mixed with barium sulphate, how could you detect the adulteration ?

5. What are hydrocarbons and where are they found ? Mention three hydrocarbons present in illuminating gas.

6. Why does the air of a tightly closed room in which lamps are burning become unfit to breathe ? What is the explanation of the explosions which often occur in houses when illuminating gas has been escaping ?

7. What is the purpose in using baking soda in dough? Why does a lamp burn better with the chimney on than off?

8. Describe the manufacture of white lead, giving equations and uses.

9. Discuss combustion, the nature of a flame, and the factors which cause and modify the luminosity of a flame.

10. Describe fully the oxides of carbon and the ways in which they are formed and prepared.

11. Point out the chemical similarity between carbon and silicon.

12. Give (a) the equation for the combustion of carbon monoxide in oxygen. (b) What will be the relative volumes of the gases taking part in the reaction? (c) What will be the relative weights of the gases? (d) If 56 g. of carbon monoxide are used, what will be the volumes of oxygen required under standard conditions?

13. Calculate the volume occupied by 10 g. of carbon dioxide at 27° C. and 38 cm. pressure, assuming that 1 g. of CO_2 at 0° C. and 76 cm. occupies .509 l.

14. Calculate the weight of sodium hydroxide that would react with 22.4 l. of CO_2 under normal conditions of temperature and pressure, sodium hydroxide to be in excess.

15. State from personal experience how CO_2 was prepared in the laboratory, and write the reaction involved. State two properties of CO_2 which were ascertained by experiment. How may it be shown that CO_2 is one of the products of respiration?

16. What do you consider the most important compound of (a) carbon? (b) silicon? (c) tin? (d) lead? Why?

17. How does the total weight of the products of combustion of a candle compare with the total weight of the materials taking part in the combustion? Name and state the law which this illustrates.

18. State a chemical method of distinguishing between CO and CO₂ and describe a method by which each may be converted into the other.

19. Name an important ore of lead. How would you proceed to get metallic lead into solution? Give the formula of the resulting compounds of lead.

20. Name two natural and two artificial modifications of the element carbon. What are the chief products resulting from the heating of soft coal without access of air? How does coal gas differ chemically from water gas? Under what conditions does a combustible substance burn with a flame? Name two purposes for which graphite is commonly used.

21. Name the substances used in the manufacture of glass. How does the composition of hard glass differ from that of soft glass?

22. How is water gas made? What gases does it contain? Why is it carburetted (enriched)? To what constituent is the poisonous character chiefly due?

23. Give the chemical name and the mineralogical name of one important ore of lead. Describe briefly the mode of extracting the metal, name two practical uses to which it is put, and state what property renders it particularly suited to each purpose named. What metals are components of solder and brass?

24. Discuss the chemical changes which take place in a furnace fire, as follows:

1. What substances cause the blue flame at the surface of the coal and how is it formed?
2. State and give reasons for the effects of admitting air (*a*) to the top of the fire; (*b*) to the bottom.
3. How does anthracite coal differ from bituminous in appearance and chemical quality?

25. Draw a vertical section (diagram of a candle flame), showing its structure. Indicate on the diagram the part of the flame having (a) greatest luminosity; (b) greatest heat.

26. Find the weight of each of the products of combustion when 78 g. of acetylene are burned.

27. Write in order the chemical name and the formula of each of five members of the marsh-gas series.

28. Describe the process of fractional distillation of petroleum. Mention three useful products derived from it, with formulas.

29. Distinguish as to chemical composition and properties between fire damp and choke damp and explain why each is dangerous in mines.

30. Describe in detail a process of manufacturing lead carbonate on a commercial scale. State the principal use of it.

31. Give the construction of the Davy safety lamp and describe a laboratory experiment to illustrate the principle on which its safety depends.

32. Describe the construction and explain the operation of a Bunsen burner.

33. Compare the action of carbon and chlorine as disinfecting agents.

34. Give the theory to account for the formation of (a) petroleum; (b) natural gas.

35. Describe a method of preparing acetylene and state its physical and chemical properties.

36. (a) Explain the formation of marsh gas in nature. (b) Distinguish between carbohydrate and hydrocarbon. (c) Mention two groups of carbohydrates.

37. Describe the manufacture of glass and distinguish between window glass and green bottle glass.

38. Mention (a) the principal products obtained from the destructive distillation of bituminous coal; (b) two great natural sources of CO_2 . (c) Explain why the percentage of CO_2 in the air remains nearly uniform.

39. Describe the preparation and give the properties and uses of (a) lampblack; (b) coke. (c) What is the source of gas carbon and its use?

40. If a candle consists of 87 per cent carbon and of 13 per cent hydrogen, what weights of CO_2 and of H_2O will be formed when 50 g. of the candle burn?

41. What weight of CO will be formed upon treating 25 g. of oxalic acid with concentrated sulphuric acid?

42. Name the natural and artificial forms of free carbon and state how they differ from one another.

43. What volume of CO_2 would be formed respectively by the complete combustion of (a) 12 l. of acetylene? (b) 7 l. of propane (C_3H_8)? (c) 75 cc. of CO? (d) 2.5 l. of methane? (e) 4 l. of ethylene (C_2H_4)?

44. Through what cycle does carbon pass in animal and vegetable life?

45. How may coke be converted into graphite? What is animal charcoal? For what purpose is it used?

46. Describe (a) the process employed in the manufacture of carborundum. Of what practical use is the substance? (b) In what forms does silica occur in nature? In what industry are silica and the silicates of great importance?

47. Calculate the weight of calcium carbonate that could be precipitated by the action of 10 l. of CO_2 (measured under 745 mm. pressure at 21°C .) upon a solution of $\text{Ca}(\text{OH})_2$.

48. Name three allotropic forms of carbon and show how their chemical identity may be proved. By what reaction may CO_2 be distinguished from CO?

49. What is allotropy and how is it illustrated and accounted for in the case of the element carbon?

50. Name three important substances obtained by the destructive distillation of (a) wood; (b) soft coal.

51. What is an alloy? Mention an alloy and state three ways in which its properties differ from those of its constituents. Name an alloy of lead and of tin.

52. Make a comparison between (a) carbon and silicon as to compounds formed; (b) between carbon, oxygen, sulphur, and phosphorus as to allotropic forms.

53. Suggest a probable way that natural gas has been formed.

54. Coal frequently contains sulphide of iron. What sulphur compounds are likely to be formed when gas is made from such coal, and what would be the method for the removal of these compounds?

55. Could a solution of NaOH be substituted for the solution of $\text{Ca}(\text{OH})_2$ in testing for CO_2 ?

56. How would you distinguish between CO_2 , and O, H, N, and N_2O ?

57. How would you distinguish between carbonates and sulphites?

58. Write the equations for the preparation of MgCO_3 , BaCO_3 , K_2CO_3 , Na_2CO_3 , and CaCO_3 .

59. How would you detect the presence of lead in tinfoil?

60. Since stannous chloride reduces gold chloride, give the equation for extracting gold.

61. What sulphates other than lead are insoluble?

62. (a) In what respect is silica similar to tin and lead?
(b) Given one ton of cassiterite, how much tin could be obtained by its reduction?

63. How can you determine whether a given crystal is quartz or calc-spar?

64. Dumas, in 1859, added to a solution containing 4.5049 of stannous chloride an excess of a solution of silver nitrate and found that the precipitate of silver chloride formed contained 7.481 g. of silver. What is the atomic weight of tin, if the atomic weights of Cl and Ag are 35.43 and 107.94 respectively?

65. Explain the principle of the chemical fire extinguisher, state what materials are used, and give the equation.

66. Give the most important use of silicon dioxide and explain why silicon is not found free in nature.

67. What is water glass? How is it produced and what are its uses?

68. Calculate the percentage of CO_2 and CO and restate the percentages in a form which illustrates the Law of Multiple Proportions.

69. A gaseous hydrocarbon contains 85.71 per cent of carbon; its density referred to oxygen is .875. What is its simplest formula and its molecular formula?

70. Write the formulas for the following compounds: silicon iodide, hydrogen silicide, silicon sulphide, carbon silicide.

71. Write the equations for the preparation of silicic acid; carbonic acid. Write the formulas of the following: lead sodium acetate, stannous bromide, thorium nitrate, cerium sulphate, lead chromate, lead sulphide, lead tetroxide, stannic chloride, stannous sulphide, stannic oxide.

72. Thorium is much like what other newly discovered element?

73. How is animal charcoal obtained?

74. Describe the manufacture of shot, touching on (*a*) substances used; (*b*) processes used. Explain each process mentioned. Why is arsenic used in the manufacture of shot?

75. Give a laboratory method of preparing each of the oxides of carbon. Compare the chemical properties of these oxides and state the effects of each on animal life. Explain the formation of each in a coal fire.

CHAPTER XIV

THE HALOGENS

1. How may chlorine, bromine, and iodine be prepared? Write the equation representing the reaction involved in each case. Why are these elements grouped together?

2. Describe another method for the preparation of chlorine and write the equation for the reaction involved.

3. Why is moisture necessary to the bleaching action of Cl? What is formed when hydrogen burns in chlorine and how may the product be distinguished from chlorine?

4. (*a*) How may chlorine be prepared? State its properties. (*b*) What elements constitute the halogen group and why are they grouped together?

5. Give the properties of Cl and state what is formed when it is passed into a hot concentrated solution of potassium hydroxide.

6. What weight of chlorine will be set free when a solution containing 75 g. of sodium chloride is electrolyzed, and what will be the volume of the chlorine gas thus made at a temperature of 20° C. and a pressure of 740 mm.?

7. How many liters of chlorine can be obtained from 100 g. of common salt?

8. Name the principal characteristics of each of the halogens in the free state. Why are they grouped together? Describe a method for the laboratory preparation of free bromine and write the reaction.

9. What is the chief source of iodine in commerce? What are its properties? How may its presence be detected?

10. Calculate the approximate weights in grams of 1 l. of each of the following gases: Cl_2 , HCl , HBr , HF .

11. What weight of chlorine can be prepared from 78 g. of rock salt containing 99 per cent NaCl ? How much manganese dioxide and sulphuric acid would be required to carry out the reaction? What volume would the chlorine occupy under standard conditions? What volume of hydrochloric acid would be formed?

12. Write the equation for preparing hydrofluoric acid. Describe and explain the process of etching glass. State two methods of identifying iodine.

13. Describe and explain the action which occurs when chlorine water is added to a solution of potassium iodide containing starch.

14. If 100 g. of magnesium are completely dissolved in hydrochloric acid, what volume will be occupied at 18°C . and 760 mm. by the gas evolved? If this gas is then burned in oxygen, what substance will be produced and how much?

15. If a quantity of a gas measures 493 l. at 784 mm. and 20°C ., what will be its volume under standard conditions? Supposing the gas to be hydrogen chloride, calculate its weight. What weights of materials would be required to prepare it?

16. What occurs when Cl is passed into (a) a cold and dilute solution of potassium hydroxide, and (b) into a hot and concentrated solution?

17. Mention some important chlorides formed in nature; some that are artificially produced.

18. Describe in detail the process of bleaching, giving the reaction involved.

19. What is chlorinization? What are the tests for chlorine and the chlorides?

20. Give the reaction involved in the process of disinfecting with Cl.

21. Name the acids of Cl and write and name the zinc salt of each.

22. Compare the elements of the halogen group as to (a) state, (b) color, (c) weight, (d) chemical activity.

23. Calculate the volume of hydrochloric acid solution, density 1.1 and 20 per cent pure acid by weight, that would be required to neutralize 50 g. of $\text{Ca}(\text{OH})_2$.

24. How may Cl and HCl gas be obtained, starting from common salt in each case? In what chemical way may these two substances be distinguished from each other?

25. Give reasons why the halogens are regarded as members of a natural group of elements.

26. How do you ascertain the properties of HCl and how, in addition, could you show that this compound contains (a) hydrogen? (b) chlorine?

27. Describe the preparation of HCl as a by-product in the manufacture of sodium carbonate. Give its physical and chemical properties.

28. Describe in detail an experiment illustrating the bleaching properties of Cl.

29. Give the important physical and chemical properties of iodine. Mention one source and two uses of iodine.

30. Write equations for the preparation of potassium bromide by three different methods.

31. If a solution contains potassium bromide and potassium chloride, how would you show the presence of the halogens?

32. How do you account for the fact that solutions of hydriodic acid become dark on standing some time?

33. Write the equations for the reactions of bromine with zinc, water, antimony, and hydrogen.

34. How many liters of N may be obtained by the interaction of Cl with NH_3 ?

35. If the weight of 1 l. of HCl gas is 1.735 g., what is the elemental weight of chlorine?

36. How many grams of NaCl are required to prepare half a kilogram of hydrogen chloride?

37. The analysis of a certain compound gave the following results:

1. C = 12.00 per cent	2. 11.69 per cent	3. 11.83 per cent
H = 3.98 per cent	4.02 per cent	4.00 per cent
N = 6.77 per cent	6.80 per cent	6.78 per cent
Br = 77.56 per cent	77.61 per cent	77.64 per cent

What was the formula?

38. A saturated solution of Cl when exposed to sunlight yielded 20 cc. of a gas. How would you establish the identity of the gas and how much Cl was required to produce it?

39. $\text{CaO} + 2 \text{NH}_4\text{Cl} = 2 \text{NH}_3 + \text{H}_2\text{O} + \text{CaCl}_2$. Given 56 grains of lime, how many cu. ft. of ammonia at 0°C . and 15 lb. pressure would result from the above reaction?

40. Write the formulas for the following compounds: magnesium iodide, mercuric bromide, silicon fluoride, ferrous bromide, ferric chloride, lead iodide.

CHAPTER XV

THE ALKALINE-EARTH METALS

1. What reaction takes place when magnesium flash-light powder is set on fire?

2. The gas density of mercury is 100. What is the formula for the molecule? Why is nitric acid a better solvent for Hg than hydrochloric?

3. What is the approximate specific heat of cadmium, accepting 112 as its atomic weight?

4. How much Hg is formed by decomposing 500 g. of cinnabar?

5. Write the formulas for the following compounds: mercuric sulphate, mercuric iodide, mercurous bromide, cadmium sulphate, cadmium iodide, zinc iodide, zinc acetate, potassium zincate, magnesium fluoride, magnesium phosphate, ammonium magnesium phosphate, magnesium iodide.

6. What properties have the metals of the magnesium family in common with the alkali metals? with the alkaline-earth metals?

7. Distinguish between magnesium chloride and magnesium sulphate; between Epsom salts and Glauber salts.

8. What hydroxide studied, other than zinc hydroxide, has both acid and basic properties?

9. What property of Mg is made use of in the isolation of argon?

10. Erdman and Marchand, in 1844, obtained 352.4079 g. of mercury by heating 380.5744 g. of mercuric oxide. What is the atomic weight of mercury?

11. How may quicklime be prepared? What chemical change takes place in the drying of ordinary mortar?

What substances ordinarily cause temporary and permanent hardness in water? Write the equation representing the reaction involved in the removal of temporary hardness by boiling.

12. Name four forms in which calcium carbonate occurs in nature. How may quicklime be prepared? What happens when water is added to quicklime? What is plaster of Paris and from what is it made?

13. What is meant by radioactivity? What is the present source of radium? What are the effects of the rays given off from radium?

14. Explain in detail how such elements as sodium and calcium can be detected with the aid of the spectroscope.

15. The most important ore containing mercury is cinnabar (HgS). Where is it found? How is the mercury extracted from it? What are the commercial names of mercurous chloride and mercuric chloride and how do the two differ from each other in chemical properties?

16. How many grams of quicklime and how many liters of CO_2 would be formed by heating 1 kg. of limestone?

17. What substances ordinarily cause temporary and permanent hardness of water respectively? Explain the chemistry involved in the removal of temporary hardness and give the equation expressing the reaction.

18. What weight of Zn would be required for the production of sufficient hydrogen, at 21°C . and 745 mm. pressure, to fill a balloon having a capacity of 100 cc.?

19. What weight of calcium carbonate is required to neutralize 400 cc. of hydrochloric acid solution which contains 100 g. of the pure substance?

20. A flask has a capacity of 15 l. The prevailing temperature is 18°C . and the atmospheric pressure is 752 mm.;

what weight of Zn, reacting with H_2SO_4 , would be needed to fill the flask with hydrogen under the prevailing conditions?

21. How is lime prepared? What is the action of the atmosphere upon it? What is mortar? How is it prepared and what chemical changes occur when it hardens?

22. What is the specific heat of cadmium if its atomic weight is 112?

23. How much (a) calomel can be obtained from 200 g. of mercurous sulphate? (b) how much corrosive sublimate?

24. Hauer, in 1868, found by heating 64.2051 g. of cadmium sulphate ($CdSO_4$) that 44.4491 g. of cadmium sulphide were left. Taking the atomic weights of oxygen and sulphur as 16.00 and 32.06 respectively, calculate the atomic weight of cadmium.

25. Why is normal calcium phosphate converted into superphosphate in the manufacture of fertilizers?

26. How is a limekiln built, and why is the production of lime hastened by blowing air or steam into the kiln?

27. What is the test for a magnesium compound? for zinc? for strontium? for cadmium?

28. Name two alloys of zinc and state what each contains.

29. How is zinc obtained from its ores? Mention two ways to prepare zinc sulphide.

30. Name a compound of Zn used as a base for paint. Why is a zinc paint especially valuable in chemical laboratories?

31. What special name is given to the alloys of mercury?

32. How would you test for a soluble salt of Hg? Calculate the percentage composition of the two chlorides of Hg.

33. Give a method for making zinc chloride from the sulphate, with equations. Write equations for the reactions of a dilute solution of (a) zinc bromide, with silver nitrate; (b) sodium hydroxide; (c) chlorine; (d) ammonium sulphide.

34. Write equations showing four methods by which the salt, zinc sulphate, could be made.

35. Describe the process of converting (a) limestone into quicklime; (b) quicklime into slaked lime. Write the reaction in each case.

36. Mention three ores of zinc. Describe the ordinary method of extracting zinc from the ores mentioned. Write the reaction.

37. Give the physical and chemical properties of Zn and describe the process of galvanizing and explain its use.

38. Show by equation how the following compounds of zinc may be obtained from metallic zinc: the oxide, chloride, nitrate, carbonate, sulphate, sulphide, hydroxide.

39. Write the equation for the reaction between barium chloride and sulphuric acid in (a) the ordinary chemical form and (b) the ionic form.

40. If 64.2508 g. of cadmium sulphate yield 44.4491 g. of cadmium sulphide, what is the atomic weight of cadmium?

41. How is Zn obtained in a commercial scale from zinc ore? Why is it used for galvanizing iron wire? What compound of Zn is used in the manufacture of paint? Define the terms "alloy" and "amalgam" and give an example of each.

42. What is meant by radioactivity? What are *alpha* and *beta* particles? Are they electrons? Does radioactivity differ from other chemical reactions?

43. Describe, writing the equations to express the reactions in each case, the chemical changes that take place in the calcium compound from the time it leaves the quarry as limestone till it hardens into plaster on the wall.

44. Calculate the simplest formula for a compound having the percentage compositions Ca = 40, C = 12, O = 48.

CHAPTER XVI

THE ALKALI METALS

1. Write the formulas of the following compounds by applying the principles of valence: sodium fluoride, sodium phosphate, sodium chlorite, sodium acetate, potassium manganate, acid potassium sulphite, lithium carbonate, lithium chloride, lithium phosphate, potassium nitrate, sodium sulphate.

2. How much sodium will 4 kg. of sodium carbonate yield if heated with carbon?

3. Describe the preparation of potassium hydroxide from potassium carbonate and write the reaction. Give the physical and chemical properties of potassium hydroxide.

4. Describe the Solway process of manufacturing sodium carbonate. Write the reactions.

5. (a) Mention two alkali metals and give the formulas for their hydroxides, carbonates, and sulphates; (b) point out how these compounds differ in solubility from the corresponding compounds of the alkali-earth metals.

6. What is formed when a solution of sodium hydroxide is saturated with hydrogen sulphide?

7. Give a brief description of making soda from common salt and making caustic soda from soda.

8. Describe the manufacture of caustic soda from rock salt according to the electrolytic process.

9. Describe the Le Blanc process of manufacturing Na_2SO_4 .

10. Give a complete description of the action of the metal sodium upon water. Give the properties of the products of the action. Give a similar account of potassium.

11. How many grams of sodium will be needed to combine exactly with a quantity of chlorine which at 18°C . and 740 mm. occupied a volume of 200 cc.? What will be the weight of the resulting salt?

12. Describe the commercial electrolytic method of obtaining the metal sodium and write the reaction.

13. Write the equations for the

1. Action of dilute sodium hydroxide on chlorine.
2. Nitric acid neutralized by potassium hydroxide.

14. Name the potassium salt and give the formula for each of these acids: HCl , HClO , HClO_2 , HClO_3 , HClO_4 , HNO_2 , HNO_3 , H_2SO_4 , HBr , H_3AsO_4 , HF .

15. What weight of NaOH must be dissolved in 1 l. of water to yield a solution of such strength that 10 cc. of it will exactly neutralize 5 cc. of a solution of HNO_3 that contains 126 g. of the acid in 1 l.?

16. Describe in detail what happens when a solution of sodium sulphate is electrolyzed. How may the direction of the current be determined?

17. How many kilograms of crystallized sodium carbonate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) could be obtained from 1000 kg. of salt?

18. What weight of HNO_3 would be required to exactly neutralize 30 g. of NaOH , and what weight of sodium nitrate would be formed?

19. Write the equations

1. Potassium and sulphuric acid.
2. Calcium hydroxide and ammonium hydroxide.
3. Sodium hydroxide and phosphoric acid.
4. Ferric chloride and ammonium hydroxide.

20. Give the formulas for three important compounds of sodium. How are these compounds obtained and to what use are they put?

21. Write the formulas for the following compounds and name the acids of which they are salts: sodium hypochlorite, sodium chlorite, sodium chlorate, sodium perchlorate, sodium chloride.

22. What is water glass? Give two uses to which the substances may be put.

23. How many grams of potassium hydroxide are contained in 1 l. of a solution that 6.4 cc. will completely neutralize 9.6 cc. of normal solution of HCl?

24. How much sodic chloride may be obtained from 10 g. of crystallized sodic carbonate?

25. To what extent does the composition of a pure chemical compound vary? Take as an example pure sodium chloride from various sources and mention other examples if possible.

26. Discuss the use of potassium compounds as a fertilizer. State the common form and its formula.

27. Name two compounds of sodium which are commonly employed in the household and give the use of each.

28. What are constituents of common gunpowder? What is the formula for caustic potash?

29. How may $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ be converted into NaOH, and how may metallic sodium be made from NaOH? Give reactions.

30. Give the tests for sodium; for potassium; for lithium.

31. Explain the formation of potassium nitrate by nitrification.

32. In what location are sodium, potassium, and lithium produced in nature?

33. Give the chemical difference between sodium carbonate and sodium bicarbonate. What are their common names and their uses?

34. If a gram of gunpowder produces 300 cc. of gas at 0°C ., what will its volume be at 2000°C .?

35. Give the important compounds of lithium; their properties and uses. Give the properties of lithium.

36. Name all the members of this group and compare them as to common characteristics.

37. Which of these gases would you dry with solid caustic potash: oxygen, carbon dioxide, ammonia, carbon monoxide?

38. How would you prove the presence of potassium in plants?

39. Distinguish by analysis between sodium chloride and ammonium chloride.

40. How would you distinguish between KF , KI , KBr , KCl ?

41. Why does KHSO_4 react acidic, while NaHCO_3 reacts alkaline?

42. Sodium nitrate is used in the preparation of HNO_3 . Why not potassium nitrate?

43. How could you prove that the water in crystals of NaCl is not water of crystallization?

CHAPTER XVII

ALUMINUM-BORON GROUP

1. How is aluminum obtained? Is the method of electrolysis used in decomposing the more stable or the less stable compounds?

2. What care must be taken of kitchen utensils made of aluminum?

3. (a) How could you prove that alum contains aluminum? (b) What are the properties of aluminum?

4. Explain why alum turns litmus red and borax turns litmus blue.

5. What is the per cent of aluminum in (a) cryolite (Na_3AlF_6)? (b) in turquoise ($\text{Al}_2\text{P}_2\text{O}_8 \cdot \text{H}_8\text{Al}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$)?

6. Write the formulas for aluminum sulphide, aluminum phosphate, aluminum acetate, potassium aluminate.

7. Write the equation to show how aluminum hydroxide can play the part of a base; of an acid.

8. What compound of aluminum is formed when a solution of calcium carbonate reacts with a solution of aluminum sulphate?

9. Describe briefly the commercial process for the preparation of aluminum from aluminum oxide.

10. Give the properties of metallic aluminum and the name and formula of an important salt.

11. How many grams of aluminum can be obtained from 200 kg. of bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$)?

12. Describe the reaction that takes place between metallic aluminum and ferric oxide when a mixture is ignited. Give the equation and state what practical applications are made of the reaction.

13. Describe in detail the Goldschmidt process for welding iron, giving the equation expressing the reaction.

14. (a) Complete and balance the following:



(b) Is aluminum hydroxide to be regarded as an acid or as a base?

15. What is the composition of the mixture termed "thermit"? What is the chemical action that takes place between these components? What practical use is made of thermit?

16. Explain the use of aluminum sulphate in the purification of water.

17. Having solutions of magnesium sulphate, cadmium chloride, and aluminum sulphate, how would you test for the metallic ions? What is a mordant?

18. What are the products obtained by heating sodium sulphate with boracic acid?

19. How many grams of CO_2 are evolved when 200 g. of borax are made by the interaction of boric acid and Na_2CO_3 ?

20. Which contains the larger percentage of boron — boric acid, boracic acid, or boron trioxide?

21. What is the formula for ferric ammonium alum and what are its properties and uses?

22. Terreil, in 1879, found that 0.0455 g. of H was evolved when 0.410 g. of aluminum was dissolved in an acid. What is the atomic weight of aluminum calculated from this experiment?

23. What hydroxides other than aluminum hydroxide have both acid and basic properties?

24. Write the equations for the preparation of aluminum hydroxide and aluminum sulphate.

25. Write the general formula of an alum, letting M represent the atom of the alkali metal and X the atom of the trivalent metal.

26. In what respect does aluminum oxide differ from calcium oxide in properties?

27. Explain the use of borax for the "softening of water"; the use of it in the "borax bead's" test.

28. How could Al , NH_4 , and SO_4 be recognized in an alum solution? Illustrate with equations.

29. What volume of O at 15°C . and 760 mm. is needed to change 8 lb. of aluminum into aluminum oxide (Al_2O_3)?

CHAPTER XVIII

IRON, NICKEL, COBALT, PLATINUM GROUP

1. Does iron occur free in nature? Give the reason.
2. Name and compare the three varieties of iron. Why should these not be regarded as allotropic forms?
3. There are two metallurgical processes. Iron illustrates one and sodium the other. Describe each process.
4. Describe the manufacture of iron in the blast furnace.
5. Describe in detail the manufacture of pig iron from iron ore.
6. Give the tests for iron.
7. Name at least three iron ores. Describe the manufacture of cast iron. What is the flux generally used in smelting iron? Name the chief chemical changes that take place in a blast furnace. How is cast iron converted into wrought iron and steel?
8. How is steel made from pig iron by the Bessemer process?
9. Name an ore of each of the following metals: iron, lead, zinc, and mercury. Give a test for a metal in each of the following ways: (a) by flame coloration; (b) by the borax bead; (c) by the blowpipe in charcoal.
10. How may a ferrous salt be prepared? a ferric salt? Give a special test for each.
11. Name the ingredients of the furnace charge that would be employed in the manufacture of cast iron from an ore containing ferric oxide mixed with sand. Make a diagram of the furnace.
12. What weight of O is required to unite with 21 g. of iron to give the magnetic oxide of iron (Fe_3O_4)? What volume will this O occupy at 10°C . and 750 mm.?

13. Give the names of the different processes for producing steel from cast iron, and define ore and flux. Give formulas for six important compounds of iron.

14. How would you (a) make ferrous chloride from iron? (b) ferrous sulphide from ferrous chloride? (c) ferrous sulphate from ferrous sulphide? (d) ferric hydroxide from ferrous sulphate?

15. In the above question write the equations for the reactions after giving the descriptions of the processes, and indicate the color of the product in each case.

16. How can ferrous sulphate be made from iron and this compound converted into a ferric salt? How would you test for ferric oxide in the solution?

17. Both iron and aluminum become oxidized upon exposure to the air. Why does iron gradually disintegrate, and why does aluminum remain not perceptibly changed?

18. Why is iron pyrites an objectionable ore from which to obtain iron?

19. Russell, in 1869, found that the hydrogen produced by the action of HCl upon cobalt was 3.4917 per cent of the metal. Calculate the atomic weight of cobalt.

20. Write the formulas for the following compounds: potassium ferrocyanide, potassium ferricyanide, ferric ferrocyanide, ferrous ferricyanide, potassium cobalt nitrite, ferric acetate, ferric nitrate, ferrous bromide, nickelic sulphate, cobaltic nitrate.

21. Write the chemical and ionic equations for the displacement of copper by iron in solutions of copper compounds.

22. What is a slag? How is it produced and what is its use?

23. What is the method of preparation of platinum, and what metal is likely to be alloyed with it?

24. When a solution of sodium carbonate is added to a solution of a ferric salt, an hydroxide is precipitated and not a carbonate. How is this explained?

25. Give the tests for nickel and cobalt.

26. What is the only important compound of platinum, and what is the use of platinum in the contact process in the manufacture of H_2SO_4 ?

27. Distinguish between chrome iron, nickel steel, spiegel iron, and vanadium steel.

28. What is the minimum weight of carbon per ton of steel that can be added and yet have the steel take a temper?

29. Describe the open-hearth process; the Siemens-Martin process of manufacturing steel.

30. State the most important uses of cobalt, its properties, and how and when found.

31. Give the chemical and the common name of FeS . How can it be prepared in the laboratory? Give equation.

CHAPTER XIX

COPPER, SILVER, AND GOLD GROUP

1. Compare copper, silver, and gold in their physical and chemical properties.

2. What is oxidized silver, German silver, sterling silver?

3. Write the formulas for the following compounds: cuprous nitrate, cuprous sulphide, cuprous iodide, cupric acetate, silver cyanide, silver sulphate, silver oxide, aurous bromide, auric chloride, aurous hydroxide, cupric hydroxide.

4. If 500 g. of silver interact with nitric acid, how much silver nitrate is formed?

5. Write the equation for the reduction of cupric oxide by hydrogen with heat.

6. What acid would you use to dissolve silver? What chemical test would show the difference between a solution containing a silver salt and one containing a zinc salt? Write equations to illustrate both answers.

7. Write equations for the reaction between silver and nitric acid; also for the resulting solution with hydrochloric acid. Describe the visible changes accompanying these reactions.

8. Describe a process of obtaining copper from one of its ores. Mention (a) the properties of copper, and (b) the important uses.

9. Write the equation for the reaction of H_2SO_4 on copper when heated. Explain why the gaseous product obtained differs from that usually produced by the action of an acid on a metal.

10. Define cupellation. Describe a process of extracting silver from its ores by cupellation.

11. Calculate the percentage of water of crystallization in crystalline copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$).

12. An experiment showed that when 2.16 g. of silver were treated with chlorine 2.87 g. of silver chloride were formed. Calculate from this result the atomic weight of silver.

13. Describe experiments by which you could determine whether or not an alloy contained silver.

14. Name the elements that enter into the composition of the following alloys, and give the usual percentage relation: (a) aluminum bronze; (b) brass; (c) bronze; (d) German silver; (e) gold coin; (f) gun metal; (g) nickel coin; (h) silver coin.

15. How could you prepare pure silver chloride from a silver coin?

16. Account for the action of sulphur water and eggs upon silver.

17. Silver may be cleaned by boiling it in water in an aluminum vessel. Write the equation for the action involved.

18. Silver nitrate and mercuric nitrate are both white salts soluble in water. How could you distinguish between them?

19. Describe, giving chemical reactions involved, the amalgamated process of refining silver. Why is the silver sulphide first changed into silver chloride?

20. Why is silver not used as an electric conductor?

21. Describe what takes place when a solution of silver nitrate is electrolyzed (*a*) with both terminals of platinum; (*b*) with both terminals of silver.

22. What occurs when a solution of copper sulphate is electrolyzed (*a*) with both electrodes of copper? (*b*) with both electrodes of platinum?

23. (*a*) Describe the electrolytic purification of copper; (*b*) the method of electrolytic copperplating.

24. What chemical compound is ordinarily employed in photography? Describe briefly the chemistry of the different steps taken in making a photograph.

25. Draw carefully a diagram of an apparatus for passing H over red-hot oxide of copper. Include the details for making the hydrogen gas and the arrangement for preserving separately the products of the reaction.

26. State two ways by which an aqueous solution of a copper salt may be distinguished from one of a ferric salt.

27. Why is plated ware softer than sterling silver? What compound is usually formed when silver tarnishes? Mention two articles of food that cause silver to tarnish.

28. How does copper occur in nature? What is blue vitriol? Give three tests for copper.

29. If 4.393 g. of copper precipitate 14.91 g. of silver from a silver nitrate solution, and the atomic weight of silver is 108, what is the atomic weight of copper?

30. How would you account for the fact that solutions of the different salts of a metal usually have the same color?

31. How would you test for the presence of silver in an ore?

32. From 10 cc. of a solution of silver nitrate 0.9365 g. of silver chloride were obtained by precipitation with hydrochloric acid. How many grams of silver nitrate are contained in a liter of the solution?

33. Describe the chlorination and the cyanide processes for extracting gold.

CHAPTER XX

CHROMIUM AND MANGANESE GROUP

1. Name the members of the chromium group.
2. Distinguish between trivalent and hexavalent chromium.
3. Name the most important compounds of chromium.
4. Give the equation for the action of H_2SO_4 upon potassium chromate, showing all steps.
5. How is permanganate solution used as a test for organic matter in water?
6. Name (a) the most important compounds of manganese; (b) state their uses; (c) give their characteristics.
7. In the preparation of O from KClO_3 manganese dioxide is used. Explain its action and name the process.

8. How may potassium dichromate be converted into potassium chromate and vice versa?

9. What is chrome iron, and what is the purpose in using chromium in iron?

10. Give the tests for Mn and for chromium.

11. Write the equations for the following reactions:

1. Preparation of manganous chloride.

2. Preparation of manganous hydroxide.

3. Ferrous sulphate + potassium permanganate =

4. Ammonium sulphate + chromium sulphate =

5. Potassium chromate + hydrochloric acid =

12. How many grams of lead chromate can be made from 500 g. of potassium dichromate?

13. Why is chrome alum called a double salt? What is the meaning?

14. How is manganese classified in the groups of the elements?

15. Describe the use of manganese in the manufacture of Cl by the Weldon process, and give the reactions.

16. What is known of molybdenum, tungsten, and uranium?

17. What is meant by the term "catalysis"? Give a reaction in which a catalytic agent is used.

18. What evidence is there from the study of chromium and its compounds that oxygen is correctly called acid former?

19. How does $K_2Cr_2O_7$ prevent the "polarization" of a voltaic cell? What chromium compound is formed in the "dichromate" battery?

20. Exactly 20 cc. of a solution containing 15.8 g. of $KMnO_4$ per liter were needed to react completely with a solution of H_2O_2 . How much H_2O_2 was there?

CHAPTER XXI

ORGANIC ACIDS AND COMPOUNDS

1. What are hydrocarbons and where are they found in nature? Name some hydrocarbons which occur in illuminating gas, and show how you would prepare any one of them. Give the equations.

2. What volume of ordinary air would be required for the complete combustion of 15 l. of methane, and what weight of CO_2 would be formed?

3. State two physical properties of acetylene. Why does it give out light when burned in the air? Explain the structure and principle of the acetylene burner designed to prevent the gas from burning with a smoky flame. What two products of combustion are formed when the gas burns in air? How may the presence of each be detected?

4. What is the essential character of the common animal fats? Explain the process of soap making. What is the difference between "hard" and "soft" soaps?

5. Determine the molecular formula for a compound made up as follows: carbon 80 per cent; hydrogen 20 per cent; vapor density 15.

6. The formula for ethane is C_2H_6 . Calculate the specific gravity of its vapor (*a*) compared with hydrogen; (*b*) compared with air.

7. Find the proportions by weight and by volume in which ethane gas (C_2H_6) will combine with oxygen.

8. What is a soap? Name two soaps soluble in water; one not soluble in water. Describe a process for making soap.

9. Mention (*a*) four hydrocarbons; (*b*) four carbohydrates. Write the formula of each compound mentioned.

10. Describe an experiment to show the presence of each of the following in kerosene oil: (a) carbon; (b) hydrogen.

11. Mention three organic acids. State the physical and chemical properties of each.

12. Find the weight of each of the products of combustion of 52 g. of camphene ($C_{10}H_{16}$).

13. Describe a method of preparing sulphuric (common) ether, and mention its properties and uses.

14. Describe the changes that take place when grape juice undergoes (a) alcoholic fermentation; (b) acetic fermentation, and write the reaction in each case.

15. Write the graphic formula for marsh gas and find its percentage composition.

16. Compare common (ethyl) alcohol with wood spirit (methyl) alcohol as to (a) sources; (b) important properties and uses.

17. Name the three classes of carbohydrates and write the chemical formula for each.

18. How would you bring about the alcoholic fermentation of grape sugar? Write the equation. Give a test for each of the products of the fermentation.

19. Write the chemical formulas for the following compounds: iodoform, wood alcohol, formaldehyde, ether, acetic acid, starch, chloroform.

20. Describe cane sugar and acetic acid, touching on (a) production; (b) physical properties; (c) chemical properties; (d) chemical formula.

21. Describe the manufacture of wood alcohol, and state its properties and uses.

22. Explain the instability of organic substances and state its importance in (a) nature; (b) fuels.

23. State the eight divisions of organic compounds, and give the important members of each.

24. Compare isomerism and allotropy, and give examples of each.

25. What is saponification, and how is it illustrated?

26. Explain how collodion is related to cellulose.

27. Explain the relation of methyl chloride to wood alcohol. How is methyl chloride used in surgery?

28. Write the equation expressing the reaction that takes place when formaldehyde is prepared from wood alcohol. State the relation between formaldehyde and formalin.

CHAPTER XXII

EQUATIONS AND GENERAL FORMULAS

1. Give the formulas for borax, lime, quartz, green vitriol, caustic soda, carborundum, marble, plaster of Paris, pyrite, and cinnabar.

2. Give the name, formula, method of preparation, and use of each of two carbides extensively used.

3. Classify as acids, bases, or salts, and give name of each: NaOH , HF , NaOCl , KClO_3 , NaHCO_3 , NH_4NO_3 , NH_4OH , K_2SO_4 , $\text{Ca}(\text{OH})_2$, HNO_2 .

4. Complete the following equations, using formulas:

1. Barium chloride + sodium sulphate =

2. Hydrogen sulphide + bismuth chloride =

3. Ammonium chloride + calcium oxide =

4. Sulphur dioxide + chlorine + water =

5. Give the name and formula of a binary compound, an acid containing oxygen, a base, and a normal salt.

6. Give the chemical name of each of the following substances: calomel, brimstone, fire damp, choke damp, muriatic acid, oil of vitriol, copperas.

7. Complete, using formulas:

1. Nitric acid + sodium carbonate =
2. Ammonium chloride + caustic soda =
3. Water + metallic sodium =
4. Manganese dioxide + hydrochloric acid =

8. Give a chemical method of distinguishing between each of the following:

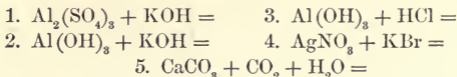
1. Hydrogen and carbon monoxide.
2. Hydrogen chloride and sulphur dioxide.
3. Oxygen and nitrous oxide.
4. Nitrogen and carbon dioxide.

9. Classify these compounds under the headings (*a*) acids, (*b*) bases, (*c*) normal salts, (*d*) acid salts, (*e*) anhydrides, (*f*) oxides: CO_2 , NaHSO_4 , CaCl_2 , PbO , H_3PO_4 , $\text{Ca}(\text{OH})_2$, NaSO_3 , MnO_2 , SO_2 , KCl , KHSO_4 , NH_4OCl , NaOH , CaF_2 , HI , NH_4OH , $\text{Ca}(\text{ClO}_3)_2$, NaNO_3 .

10. Complete the following equations, using symbols and formulas:

1. Ammonium hydroxide + hydrochloric acid =
2. Ammonia + hydrochloric acid =
3. Sodium chloride + silver nitrate =
4. Ferrous sulphide + sulphuric acid =
5. Lead nitrate + hydrogen sulphide =
6. Manganese dioxide + hydrochloric acid =
7. Calcium carbide + water =
8. Arsenic trioxide + nascent hydrogen =
9. Sodium carbonate + nitric acid =
10. Calcium hydroxide + carbon dioxide =

11. Complete and balance :

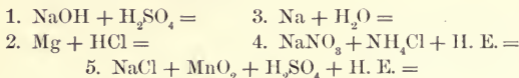


12. Give chemical names and molecular formulas for the following: borax, Epsom salts, Glauber salts, white vitriol, green vitriol, blue vitriol, iron pyrites, hematite, magnetite, potash, galena, alum, gypsum, and cryolite.

13. Classify as acids, bases, or salts, and name: H_2SO_4 , KCl , KHSO_4 , NH_4OCl , NaOH , CaF_2 , HI , NH_4OH , $\text{Ca}(\text{ClO}_3)_2$, NaNO_3 .

14. For what do the following symbols and formulas stand: SO_2 , C , CH_4 , FeO_3 , CO_2 , CaCO_3 , Hg , I_2 , H_3PO_4 , NaOH , (OH) , (NH_4) , NH_3 , Ag , Al , O_3 , S_6 , As_2O_3 , SnO_2 , and $\text{Pb}(\text{OH})_2$?

15. Complete and balance :



NOTE. H. E. stands for heat energy.

16. Write the formulas for the following compounds and name the acids of which they are salts: sodium hypochlorite, sodium chlorite, sodium chlorate, sodium perchlorate, sodium chloride.

17. Give the names of the following acids and of the sodium salt of each: HCl , HClO , HClO_2 , HClO_3 , HClO_4 , HNO_2 , HNO_3 , HBr , HI , HF .

18. Write the equations for the following reactions :

1. Silver nitrate and sodium chloride.
2. Aluminum sulphate and potassium hydroxide.
3. Ammonium chloride and slaked lime.
4. Sodium chloride, manganese dioxide, and sulphuric acid.

5. Sodium hydroxide and sulphuric acid.
6. Chlorine and potassium bromide.
7. Steam and incandescent coke.
8. Calcium carbide and water.
9. Calcium hydroxide and carbon dioxide.
10. Methane and oxygen (ignited).

19. Write the equations for the reactions between the following substances :

1. Calcium carbonate and hydrochloric acid.
2. Potassium nitrate and sulphuric acid.
3. Copper and water vapor (heated).
4. Aluminum sulphate and ammonium hydroxide.
5. Calcium carbide and water.

20. Write the formulas for the following :

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|------------------------|------------------------|
| 1. Potassium chloride. | 6. Ferrous sulphide. |
| 2. Sodium carbonate. | 7. Ferric chloride. |
| 3. Phosphoric acid. | 8. Aluminum sulphate. |
| 4. Sodium cyanide. | 9. Cuprous oxide. |
| 5. Ferric oxide. | 10. Manganese dioxide. |

21. Write the equations for the following reactions :

1. Potassium hydroxide and sulphuric acid.
2. Calcium hydroxide and sulphuric acid.
3. Calcium hydroxide and ammonium sulphate.
4. Ferric chloride and ammonium hydroxide.
5. Sodium hydroxide and phosphoric acid.
6. Ammonium nitrate and heat.

22. Write the formulas for

- | | |
|------------------------------|-----------------------|
| 1. Sodium carbonate. | 4. Arsine. |
| 2. Lead sulphate. | 5. Arsenic trioxide. |
| 3. Silica. | 6. Ammonium sulphide. |
| 7. Normal calcium phosphate. | |

23. Write the formulas for

- | | |
|--------------------------------|------------------------|
| 1. Limestone. | 5. Aluminum phosphate. |
| 2. Secondary sodium phosphate. | 6. Mercurous chloride. |
| 3. Cupric sulphate. | 7. Barium nitrate. |
| 4. Ammonia. | 8. Acetylene. |
| | 9. Gypsum. |
| 10. Marsh gas. | |

24. Classify as acids, bases, or salts: NaNO_3 , NH_4Cl , HClO , NH_4OH , BaSO_4 , $\text{Ca}(\text{NO}_3)_2$, HClO_4 , $\text{Sr}(\text{OH})_2$, HNO_2 , $\text{Fe}(\text{OH})_3$.

25. Write the formulas for

- | | |
|------------------------|--------------------------|
| 1. Barium perchlorate. | 6. Sodium perchlorate. |
| 2. Ammonium sulphate. | 7. Calcium hypochlorite. |
| 3. Strontium nitrate. | 8. Barium hydroxide. |
| 4. Calcium sulphate. | 9. Strontium oxide. |
| 5. Ferric sulphate. | 10. Barium nitrate. |

26. Complete and balance :

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|--|---|
| 1. $\text{CaCO}_3 + \text{HCl} =$ | 6. $\text{MnO}_2 + \text{NaCl} + \text{H}_2\text{SO}_4 =$ |
| 2. $\text{MnO}_2 + \text{HCl} =$ | 7. $\text{Zn} + \text{H}_2\text{SO}_4 =$ |
| 3. $\text{Al}_2(\text{SO}_4)_3 + \text{NH}_4\text{OH} =$ | 8. $\text{CaC}_2 + \text{H}_2\text{O} =$ |
| 4. $\text{CuSO}_4 + \text{H}_2\text{S} =$ | 9. $\text{H}_2\text{O} + \text{C} (\text{hot}) =$ |
| 5. $\text{KOH} + \text{H}_3\text{PO}_4 =$ | 10. $\text{Cl} + \text{KOH} =$ |
| 11. $\text{FeCl}_3 + \text{NH}_4\text{OH} =$ | |

27. Give the structural formulas of NH_4Cl , NH_4OH , and $(\text{NH}_4)_2\text{SO}_4$.

28. Complete and balance :

- | | |
|--|--|
| 1. $\text{Na}_2\text{CO}_3 + \text{HCl} =$ | 6. $\text{Ca}_3(\text{PO}_4)_2 + \text{H}_2\text{SO}_4 =$ |
| 2. $\text{CaCO}_3 + \text{HNO}_3 =$ | 7. $\text{NaOH} + \text{H}_3\text{PO}_4 =$ |
| 3. $\text{Al}_2(\text{SO}_4)_3 + \text{KOH} =$ | 8. $\text{KNO}_3 + \text{H}_2\text{SO}_4 =$ |
| 4. $\text{Zn} + \text{H}_2\text{SO}_4 =$ | 9. $\text{MnO}_2 + \text{HCl} =$ |
| 5. $\text{CuSO}_4 + \text{H}_2\text{S} =$ | 10. $\text{SO}_2 \cdot \text{NO}_2 \cdot \text{OH} + \text{H}_2\text{O} =$ |

29. Write the formulas for

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|-----------------------------|------------------------|
| 1. Marble. | 6. Ammonium phosphate. |
| 2. Primary sodium sulphate. | 7. Ammonia. |
| 3. Aluminum sulphate. | 8. Silver nitrate. |
| 4. Cuprous chloride. | 9. Mercuric chloride. |
| 5. Cupric oxide. | 10. Quicklime. |

30. Name the following: $(\text{NH}_4)_2\text{CO}_3$, NH_4HOO_3 , NH_4CN , $\text{NH}_4\text{H}_2\text{PO}_4$, Au_2O_3 , $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2$, BaCrO_4 , BiBr_3 , BiONO_3 , CsCl , NiAs , OsO_4 , $\text{K}_2\text{Al}_2\text{O}_4$, K_2PtCl_4 , $\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$.

31. Name the following: NiS_2 , NaHCO_3 , $\text{NaAuCl}_4 \cdot 2\text{H}_2\text{O}$, SeCl_2 , RuCl_2 , $\text{CaAlSi}_2\text{O}_8$, SnF_2 , SrC_2 , TaBr_5 .

32. Name the following: NaClO_4 , HClO , NO , KClO_2 , KNO_2 , C_2N_2 , H_2SO_4 , $\text{H}_2\text{S}_8\text{O}_4$, H_3PO_4 , HNaCO_3 , $\text{Ca}(\text{OCl})$, FeCl_3 , CuBr , HKCO_3 , NH_4Cl , $\text{Ca}(\text{OH})_2$, H_2O_2 , H_3PO_3 , C_2H_2 .

33. Complete the following reactions, using formulas :

1. Iron + sulphuric acid =
2. Zinc oxide + nitric acid =
3. Calcium hydroxide + carbon dioxide =
4. Marsh gas + oxygen (ignited) =
5. Hydrogen sulphide + lead nitrate =

34. Classify into acids, bases, salts, or anhydrides: SO_3 , NaNO_3 , HBr , $\text{Ba}(\text{OH})_2$, CaSO_4 , P_2O_5 , H_3BO_3 , NH_4OH , H_3PO_4 , CO_2 .

35. Complete, using formulas :

1. Ferrous sulphate + hydrochloric acid =
2. Calcium carbonate + nitric acid =
3. Sulphurous acid + sodium hydroxide =
4. Silver nitrate + potassium bromide =
5. Ferric oxide + hydrogen =
6. Phosphorus pentoxide + water =

36. Write the equations for the preparation of :
1. Carbon dioxide from calcium carbonate.
 2. Ammonium hydroxide from ammonium chloride.
 3. Chlorine from hydrochloric acid.
 4. Calcium hydroxide from calcium carbonate.
 5. Nitric acid from sodium nitrate.
37. Complete, using formulas :
1. Sodium hydroxide + carbon dioxide =
 2. Lead nitrate + hydrogen sulphide =
 3. Calcium hydroxide + nitric acid =
 4. Phosphorus + oxygen =
 5. Sodium carbonate + calcium chloride =
 6. Hydrogen + (hot) copper oxide =

State which of the above compounds are acids, bases, salts, or anhydrides.

38. Write the equations for the preparation of (a) sulphur dioxide; (b) hydrogen sulphide; (c) ammonia; (d) carbon dioxide; (e) nitric acid.

39. Give the chemical formulas for the following: diamond, carborundum, black lead, marble, sand (pure), washing soda, lye, blue vitriol.

40. State which of the reactions indicated below will take place in aqueous solution, and which will not, and give the reasons for your conclusion in each case. Complete the equations, using formulas :

1. Barium chloride + silver nitrate =
2. Calcium chloride + carbon dioxide + water =
3. Copper sulphate + zinc =
4. Ferrous sulphate + copper =
5. Calcium hydroxide + nitric acid =

41. Name two metals which have a valence of 2 and 3 respectively, and write the formulas for the nitrates and sulphates of these metals.

42. Give the chemical names and formulas for the following: baking soda, brimstone, slaked lime, litharge, quicksilver, oil of vitriol, sal ammoniac, alum, plaster of Paris, quartz, niter.

43. Write the molecular formulas for ozone, sodium sulphate, carbon monoxide, aluminum chloride, potassium hydroxide, calcium carbonate, ferric oxide, phosphorus pentoxide, lead iodide, phosphoric acid.

44. Give the names of the following formulas: $\text{Hg}(\text{NO}_3)_2$, CuO , Ag_2SO_4 , H_2O_2 , Br_2 , Au , H_2S , $\text{Pb}(\text{OH})_2$, BaCO_3 .

45. Write the formulas for nitrogen peroxide, carbon monoxide, sulphuric anhydride, calcium hydroxide, cupric oxide, stannic chloride, hydrogen bromide, potassium carbonate, silver nitrate, lead sulphate.

46. Write a list of the formulas for the oxides of nitrogen, and show how any of these can react with water. Point out how any two of this series of compounds illustrate the Law of Multiple Proportions.

47. Write equations showing laboratory methods of preparing the following: (a) hydrochloric acid; (b) sodium carbonate; (c) ferric hydroxide; (d) copper sulphate.

48. Give the chemical names and formulas for the following: quicklime, marble, blue vitriol, bicarbonate of soda, litharge, calomel. If any reactions are possible between these substances and dilute sulphuric acid, write equations to show them.

49. Write equations for the preparation of (a) CO_2 ; (b) NaOH ; (c) H_2S ; (d) AgCl ; (e) a basic oxide and HCl ; (f) an acidic oxide and KOH .

50. Describe the effects observed when chlorine water is added (a) to mercurous chloride; (b) to potassium iodide solution. What inference do you draw about the reactions that have taken place?

51. Write the chemical names of the following: H_2SO_3 , NaHCO_3 , H_2S , $\text{Fe}_2(\text{SO}_4)_3$, P_2O_5 , and show by equation how each may be prepared.

52. Write the graphic formula for (a) nitric acid; (b) calcium carbonate; (c) acetic acid.

53. Show by equation the bleaching action of (a) Cl ; (b) SO_2 .

54. Write the equations for the preparation of the following acids other than by the direct combination of the elements involved: H_2S , HNO_3 , H_2SO_4 , HBr , HCl , H_2CO_3 , H_3PO_4 .

55. Write the equations for the following reactions:

1. Potassium hydroxide and nitric acid.
2. Ferrous sulphide and hydrochloric acid.
3. Barium chloride and sodium sulphate.
4. Calcium hydroxide and ammonium chloride.

56. Write the chemical name of each of the following: KHCO_3 , AsH_3 , $\text{Ca}_3(\text{PO}_4)_2$, $\text{C}_6\text{H}_{12}\text{O}_6$, $(\text{C}_2\text{H}_5)_2\text{O}$.

57. Name and write the formulas for two oxides of phosphorus and the acid corresponding to each.

58. Write the formula and give the chemical name of saltpeter, laughing gas, sugar of lead, white vitriol, Glauber salts, corrosive sublimate, plaster of Paris.

59. Describe minutely, giving chemical equations to show the changes which take place:

1. When strong nitric acid reacts with metallic copper.
2. When hydrogen sulphide is passed into a solution of mercuric chloride.
3. When ammonium sulphate is heated with a solution of sodium hydroxide.
4. When bromine water and sulphurous acid are mixed.

60. (a) Complete, using formulas :

1. Baric nitrate + potassic sulphate =
 2. Ammonic chloride (solid) + calcic hydroxide (solid) =
 3. Sulphurous oxide + oxygen =
- (b) Give equations for making sulphuretted hydrogen.

61. Write the formulas for :

1. Three chlorides insoluble in water.
2. Four sulphates insoluble in water.
3. Two sulphides insoluble in water.
4. One carbonate soluble in water.

62. Name the following: NaClO , NO , KNO_2 , H_2SO_3 , FeCl_3 , H_3PO_4 , HPO_3 , Cu_2O , CuBr_2 , PbO_2 .

63. Write the equations for the chemical reactions below :

1. Ammonium chloride and slaked lime.
2. Manganese dioxide and hydrochloric acid.
3. Nitric acid and sodium hydroxide.
4. Sodium nitrate and sulphuric acid.
5. Manganese dioxide, sodium chloride, and sulphuric acid.

64. Write equations for the following reactions :

1. Between lead peroxide and aqueous hydrochloric acid.
2. On subliming mercuric sulphate and aqueous common salt.
3. Between aluminum sulphate and aqueous ammonia.
4. Between aluminum and potassium hydroxide.
5. Between copper sulphate and sodium hydroxide.

65. Write the formula for phosphoric acid, acetic acid, hydriodic acid, chromic acid, silicic acid, sulphurous acid, nitrous acid.

CHAPTER XXIII

QUESTIONS AND CALCULATIONS

A. PERCENTAGE COMPOSITION

1. Find the percentage composition of carbon in (a) CH_4 ; (b) C_2H_2 ; (c) C_2H_4 ; (d) COS ; (e) C_4H_{10} ; (f) $\text{C}_6\text{H}_{10}\text{O}_5$.
2. Calculate the percentage composition of the following compounds: carbon dioxide, ammonia, ferric oxide, acetic acid, calcium sulphate, cream of tartar, ferrous sulphate, alum.
3. How much sodium in (a) 10 g. of NaOH ? (b) 19 g. of Na_2SO_4 ? (c) 15 g. of NaCl ? (d) 22 g. of NaHSO_4 ?
4. Calculate the percentage composition of (a) galena; (b) pitchblende.
5. How much anhydrous salt in (a) a kilogram of crystalline Glauber salts? (b) alum? (c) Epsom salts? (d) sal soda? (e) copper sulphate?
6. Find the percentage of the elements in a sample of air which consists of 12.37 g. of N and 3.63 g. of O.
7. Calculate the percentage composition of (a) magnetic oxide of iron (Fe_3O_4); (b) crystallized sodium carbonate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$).
8. How many grams of argon can be obtained from 1500 kg. of normal air?
9. Calculate the percentage composition of (a) nitric acid; (b) potassium nitrate; (c) sodium nitrate.
10. Calculate the percentage composition of (a) alcohol ($\text{C}_2\text{H}_6\text{O}$); (b) acetic acid ($\text{C}_2\text{H}_4\text{O}_2$); (c) cane sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$); (d) acetone ($\text{C}_3\text{H}_6\text{O}$).
11. Find the percentage composition of ether.

B. ATOMIC AND MOLECULAR WEIGHTS

1. Suppose 10 g. of lead yield 14.642 g. of lead sulphate (PbSO_4). Calculate the atomic weights of S on the assumption that the atomic weights of lead and oxygen are 206.91 and 16 respectively.

2. A certain weight of copper oxide, when heated in a current of H, lost 59.789 g. of O and formed 67.282 g. of water. If O = 16, what is the atomic weight of H?

3. One gram of a certain metal was dissolved in HCl and gave 1242 cc. of H at 0°C . and 760 mm. The specific heat was found to be 23. Calculate the equivalent weight and the atomic weight. What would be the valence of the metal? the formula of the chloride?

4. Suppose 13.67 g. of a compound of lead and oxygen contained 12.39 g. of lead and 1.28 g. of oxygen; what is the formula of the compound if the atomic weight of lead is 206.9?

5. If 63.8351 g. of silver iodide yield 38.9656 g. of silver chloride, what is the atomic weight of iodine if 107.85 and 35.46 are accepted as the atomic weights of silver and chlorine respectively?

6. What is the equivalent of Ni if it dissolves in acids with the evolution of a mass of H equal to 3.411 per cent of its own mass? What is its atomic weight if it is bivalent?

7. If the atomic weight of Ag is 197.94, and if the same electric current, on passing through solutions of Ag and Cu salts, precipitates weights of the metals in the ratio of 1(Cu) : 3.408(Ag), what is the atomic weight of copper?

8. The specific heat of P is 0.189 and its vapor density referred to hydrogen is 62. How many atoms are there in a molecule of phosphorus gas?

9. Dumas synthesized silver sulphide (Ag_2S), finding the ratio of the weights of silver and of the sulphide to be 112.1943 : 128.8288. The atomic weight of silver is 107.94; find the atomic weight of S.

10. A chemist converted 16.6450 g. of bismuth oxide into 25.2551 g. of bismuth sulphate ($\text{Bi}_2(\text{SO}_4)_3$). The atomic weight of S is 32.06. Calculate that of bismuth.

11. Heinrichson heated 31.20762 g. of calcite and obtained 17.49526 g. of quicklime. If the atomic weights of oxygen and carbon are 16.00 and 12.001 respectively, what is the atomic weight of calcium?

12. A chemist obtained from 59.4763 g. of magnesium sulphate 19.9379 g. of magnesia. Calculate from this data the atomic weight of Mg.

13. If 3.17 g. of iron form 4.53 g. of Fe_2O_3 , what is the atomic weight of iron?

14. If 200 parts of BaCl_2 give 224.2 of BaSO_4 , what is the atomic weight of barium?

15. The molecular weight of lead oxide (PbO) is 221.3. The per cent of lead is 92.81. Specific heat of lead is 0.031. What is its atomic weight?

16. The specific heat of Ag is 0.056. What is its atomic weight?

17. If 4.5 g. of Hg unite with oxygen to form 4.86 g. of mercuric oxide, and the specific heat of mercury is 0.032, what is its atomic weight?

18. A metal yields a chloride containing 66.14 per cent of chlorine and having the specific gravity 7.44. What is its atomic weight?

19. Dumas found that 2.399 g. of aluminum chloride required 5.802 g. of silver for the complete precipitation of the chlorine. Calculate the atomic weight of aluminum.

Calculate the molecular weights of the following :

20. NH_4Cl ; $(\text{NH}_4)_2\text{CO}_3$; NH_4HCO_3 ; $(\text{NH}_4)_2\text{CrO}_4$; NH_4CN ;
 NH_4F ; $(\text{NH}_4)_2\text{MgO}_4$; NH_4NO_3 ; NH_4NO_2 ;

21. CaCO_3 ; CaAl_2O_4 ; $\text{Ca}(\text{HCO}_3)_2$; CaO ; $\text{Ca}(\text{ClO}_3)_2$; CaF_2 ;
 $\text{Ca}(\text{OH})_2$; CaI_2 ; CaSO_4 ; CO_2 ;

22. $\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$; FeCl_3 ; FeCO_3 ; Fe_3O_4 ; FeS ;

23. $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$; $\text{Pb}(\text{BO}_2)_2 \cdot \text{H}_2\text{O}$; PbBr_2 ; $\text{Pb}(\text{NO}_3)_2$;
 PbO ; Pb_3O_4 ;

24. MgF_2 ; $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$; MnCl_2 ; $\text{Mn}(\text{OH})_2$; HgCl_2 ;
 HgSO_4 ;

25. NiAs ; $\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2$; NiCO_3 ; HNO_3 ; N_2 ; N_2O ; NOCl ;

26. SnO_2 ; $\text{Sn}_2\text{Fe}(\text{CN})_6$; SnF_2 ; SrBr_2 ; SrC_2 ; $\text{Sr}(\text{BrO}_3)_2 \cdot$
 H_2O ; H_2SO_4 ; SOBr_2 ; TaBr_5 ;

27. $\text{Mn}_2\text{O}_3 \cdot \text{H}_2\text{O}$; $(\text{CaBa})\text{CO}_3$; $\text{CaCO}_3(\text{MgFe})\text{CO}_3$; KAlSi_3O_8 ;
 $(\text{K}_2\text{Ba})\text{Al}_2\text{Si}_4\text{O}_{12}$; $(\text{NaK})\text{AlSi}_3\text{O}_8$.

C. SIMPLEST FORMULAS

1. Calculate the simplest formula for the compounds having the percentage composition (a) $\text{N} = 82.35$, $\text{H} = 17.64$;
 (b) $\text{N} = 26.17$, $\text{Cl} = 66.35$, $\text{H} = 7.48$.

2. Calculate the simplest formula for the substances having the composition (a) $\text{O} = 76.19$, $\text{H} = 1.58$, $\text{N} = 22.22$;
 (b) $\text{N} = 13.86$, $\text{K} = 38.61$, $\text{O} = 47.52$.

3. Find the simplest formulas for the substances having the following composition: (a) $\text{H} = 1.58$, $\text{N} = 22.22$,
 $\text{O} = 76.19$; (b) $\text{O} = 47.53$, $\text{N} = 13.86$, $\text{K} = 38.61$.

4. Calculate the simplest formula for the compounds having the percentage composition: (a) $\text{N} = 82.353$, $\text{H} = 17.647$;
 (b) $\text{O} = 30$, $\text{Fe} = 70$; (c) $\text{H} = 1$, $\text{C} = 12$, $\text{K} = 39$, $\text{O} = 48$.

5. What is the simplest formula for a compound having the composition $\text{H} = 7.69$ and $\text{C} = 92.3$?

6. Calculate the simplest formulas for the substances having the composition (a) C = 40, H = 6.67, O = 53.33; (b) C = 16.8, H = 5.26, N = 36.84, S = 42.1; (c) C = 54.55, H = 9.09, O = 36.36.

7. Calculate the formulas for the following:

Cu = 34.46. CaO = 43.45. Ag = 53.15. Lithia = 6.43.
 Fe = 30.59. Al₂O₃ = 17.68. Cu = 31.08. Alumina = 29.26.
 S = 34.95. SiO₂ = 38.87. S = 15.77. Silica = 64.31.

8. What is the simplest formula for a mineral whose percentage composition is as follows: Ca, 50.12 per cent; C, 12.04 per cent; and O, 47.84 per cent.

9. A liter of gas weighs 1.16 g. Is its formula CH, C₂H₂, or C₄H₄?

10. The analysis of a certain compound gave the following results:

1. C = 12.00	2. 11.69	3. 11.83
H = 3.98	4.02	4.00
N = 6.77	6.80	6.78
Br = 77.56	77.61	77.64

What is its formula?

D. MOLECULAR FORMULAS

1. The vapor density of steam is 9. The percentage composition of water is H = 11.11, O = 88.89. What is the formula of steam?

2. Find the formula for a hydrocarbon that contains an equal number of hydrogen and carbon atoms, and the vapor of which has a density (air) of 2.

3. If 750 cc. of CO weighs 0.94 g., what is the molecular weight of the compound?

4. Calculate the formulas for the compounds having the following percentage composition and vapor density :

1. C = 92.3 per cent, H = 7.7 per cent, vapor density = 39.

2. C = 73.8 per cent, H = 8.7 per cent, N = 17.5 per cent, vapor density = 80.2.

3. C = 39.9 per cent, H = 6.7 per cent, O = 53.4 per cent, vapor density = 30.5.

4. C = 10.04 per cent, H = 0.84 per cent, Cl = 89.12 per cent, vapor density = 59.7.

5. The vapor density of Cl is 35.45. What is its molecular weight ?

6. What is the formula for mercuric chloride as deduced from the following data: weight of flask full of vapor at 350° and 758.4 mm. = 27.401 g; capacity of flask = 250 cc.?

7. The specific heat of P is 0.189 and its vapor density referred to H is 62. How many atoms are there in a molecule of phosphorus gas?

8. The gas density of sodium vapor is 11.5. Calculate the number of atoms in a molecule of sodium vapor.

9. A gaseous compound of H and C is found to contain 12 parts by weight of carbon to 1 part of hydrogen. Its gas density is 13. What is its formula?

10. If 1500 cc. of CO gas weigh 1.8816 g., what is the molecular weight of the compound?

11. Calculate the molecular formulas for the compounds corresponding to the following data :

1. C = 73.8, H = 8.7, N = 17.1, vapor density = 5.03.

2. C = 92.3, H = 7.7, vapor density = 2.425.

3. C = 39.9, H = 6.7, O = 53.4, vapor density = 1.906.

Vapor density in each case is referred to oxygen.

12. An oxide of carbon contains 42.85 per cent of carbon. Calculate the molecular formula if a liter of the gas weighs 1.25 g. under standard conditions.

13. A volatile liquid contains 37.5 per cent of carbon, 50 per cent of oxygen, and 12.5 per cent of hydrogen. A liter of the vapor weighs about 16 times that of hydrogen. What is the molecular formula?

14. If a hydrocarbon contains 80 per cent carbon and a liter of it weighs 1.346 g., what is its formula?

15. Employ Avogadro's hypothesis in calculating the atomic weight of oxygen from the following data: carbonic acid gas, steam, laughing gas, and sulphurous anhydride contain in the order named 72.73, 88.89, 36.364, and 50.00 per cent by weight of oxygen; and their densities referred to H are, in the same order, 22, 9, 22, and 32.

16. A gas has the formula C_3H_8 . Is it lighter or heavier than air?

17. A liter of arsine weighs 3.49 g. under standard conditions; find its molecular weight.

18. What is the molecular weight of marsh gas, 3 l. of which weigh 2.15 g.?

19. Calculate the molecular weights of the following gases from their vapor densities: (a) chlorine, 35.5; (b) hydrochloric acid, 18.25; (c) ammonia, 8.5; (d) nitrogen, 14; (e) steam, 9.

20. Sulphur dioxide is 2.22 times as heavy as air; find its density and the molecular weight.

21. The specific gravity of ammonia compared to hydrogen is 8.5. What is its molecular weight? Explain the steps by which it is obtained.

22. At what temperature does air have the density of H at $0^\circ C$.?

CHAPTER XXIV

WEIGHTS AND VOLUMES FROM EQUATIONS

1. What weight of hydrogen will be required for the complete reduction of 10 g. of CuO ? What will be the volume at a temperature of 15°C . and 740 mm. pressure?

2. What weight of potassium chlorate (KClO_3) would be needed to generate sufficient oxygen to fill a cylinder of 50 l. capacity under a pressure of 1000 cm. of mercury and a temperature of 15°C .?

3. The capacity of a balloon is 10,000 cu. ft. How much would it cost to fill it with hydrogen at a pressure of 800 mm. and at a temperature of 23°C ., the H being made from Zn costing 20 ct. per pound and sulphuric acid costing 8 ct. per pound?

4. What weight of ammonium chloride will yield 1 l. of ammonia at a pressure of 740 mm. and a temperature of 22°C .?

5. What would be the volume under standard conditions of a quantity of air that occupies 200 cc. at 20°C . under a pressure of 740 mm. of mercury?

6. How many liters of nitrogen monoxide can be prepared from 100 g. of ammonium nitrate?

7. What volume of a solution of H_2SO_4 that contains 40 g. of H_2SO_4 in one liter will be required for the exact neutralization of 10 cc. of a solution of NaOH containing 20 g. of NaOH to one liter?

8. What volume of ammonia gas, temperature 20°C ., pressure 740 mm., can be obtained from 214 g. of sal ammoniac, and how should one proceed to prepare it?

9. How much sodic chloride may be formed from 10 g. of crystallized sodic carbonate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$)?

10. How much CO_2 by weight and by volume can be obtained from 53 g. of sodium carbonate? What volume would the gas occupy at 20°C . and 750 mm. pressure?

11. Calculate the volume of CO_2 at 0°C . and 760 mm. that can be made from 50 g. of calcium carbonate and an excess of HCl .

12. What volume will 25 kg. of oxygen occupy at a temperature of 18°C . and a pressure of 740 mm.?

13. What weight of sulphur is necessary to produce 100 l. of SO_2 at a temperature of 20°C . and a pressure of two atmospheres?

14. How many cubic centimeters of H_2SO_4 , containing 49 g. of H_2SO_4 per liter, will be required to neutralize 2 g. of NaOH ?

15. Find the number of grams of H_2SO_4 required to unite with 176 g. of iron sulphide to form H_2S .

16. How many liters of oxygen at standard conditions would be formed by the complete decomposition of 25 g. of mercuric oxide?

17. How many tons of oil of vitriol containing 70 per cent H_2SO_4 are needed to convert 100 t. of salt into salt cake?

18. How much sulphuric acid and potassium nitrate would be required to prepare 100 g. of HNO_3 ?

19. Compute the weight of KOH required for the exact neutralization of the total quantity of HCl obtained from 175.5 g. of NaOH by the action of H_2SO_4 .

20. A solution of 5 g. of potassium iodide is precipitated with silver nitrate. What will be the weight of the precipitate of silver iodide?

21. If sodium nitrate, ammonium nitrate, and potassium nitrate were the same price per pound, which would be cheapest to use for preparing nitric acid, and why?

22. What relative weights of cupric oxide and cuprous oxide are procurable from the same weight of copper?

23. Compare the weights of aluminum and zinc necessary for the production of equal weights of hydrogen by the interaction with an acid.

24. What weight of H_2SO_4 can be prepared from 100 g. of sulphur?

25. What weight of potassium bromate can be obtained by neutralizing 1520 g. of bromine with potash?

26. What weight of limestone is needed to convert 90 tons of soda crystals into sodium bicarbonate?

27. How many grams of CO_2 will combine with 100 g. of CaO to form CaCO_3 ?

28. How much CaSO_4 can be formed from 37 g. of CaCl_2 ?

29. What weight of Al_2O_3 will be needed to prepare 94.8 g. of potash alum?

30. What weight of sodium carbonate can be made from 500 kg. of common salt?

31. Assume that thermit contains 75 per cent iron oxide; how much of the mixture would be required to produce 6 lb. of metallic iron?

32. Find the oxygen necessary to burn 100 g. of CS_2 .

33. How many grams of iron sulphide are necessary to prepare 100 l. of hydrosulphuric acid when the laboratory conditions are 17°C . and the pressure 740 mm.?

34. What weight of sodium chloride is necessary to prepare sufficient hydrochloric acid to saturate 1 l. of water under standard conditions?

35. On the supposition that calcium carbide costs 12 ct. a kilogram, what would be the cost of an amount sufficient to generate 100 l. of acetylene measured at 20°C . and 740 mm.?

36. What weight of sodium carbonate crystals will 1 kg. of the anhydrous salt yield?

37. Write the equations for the preparation of 3 kg. of KOH by three different methods.

38. Supposing bauxite to be aluminum hydroxide, what weight of it is necessary for the preparation of 100 kg. of Al?

39. How much water is necessary to convert 50 g. of P_2O_5 into hydrogen phosphite?

40. How much carbon would be necessary to convert 50 g. of CuO into pure copper?

41. How much nitric and sulphuric acid is needed to prepare nitric acid enough to exactly neutralize 5 lb. of chalk?

42. How many tons of coke containing 97 per cent carbon are required to reduce 388 t. of hematite?

43. In burning 27 g. of alcohol find the weight of the products.

44. What weight of Cl can be prepared from 78 g. of rock salt containing 99 per cent NaCl? How much MnO_2 and H_2SO_4 would be required to carry out the reaction? What volume would the Cl occupy under standard conditions, and what volume of HCl would be formed?

45. How much metallic iron can be made by reducing 230 g. of ferric oxide?

46. Calculate the volume of a solution of H_2SO_4 , density 1.8 and containing 89 per cent pure acid, that would be required to make 200 g. of HCl by acting on sodium chloride.

47. What weight of ammonium chloride, when acted upon by calcium hydroxide, is required to produce 17 g. of ammonia gas, and what weight of calcium chloride is formed at the same time?

48. To neutralize completely 196 g. of H_2SO_4 , what weight of crystallized sodium carbonate ($\text{Na}_2\text{CO}_3 \cdot 10 \text{H}_2\text{O}$) is required? The volume of CO_2 evolved is approximately 4450 cc. under standard conditions. Calculate its volume at 890 mm. pressure and 27°C .

49. What volume of nitrous oxide (N_2O) measured at 0°C . and 750 mm. would be evolved by the decomposition of 10 g. of ammonium nitrate, assuming the weight of 1 l. of nitrous oxide at 0°C . and 760 mm. to be 1.97 g.?

CHAPTER XXV

MISCELLANEOUS QUESTIONS AND PROBLEMS

1. Mention the constituents of water and give their properties by volume and by weight. Compare them as to physical and chemical properties.

2. State and illustrate the Law of Multiple Proportions.

3. Find the percentage composition of H_2SO_4 . How many grams of SO_2 can be set free by the action of 325 g. of the acid on copper?

4. Describe the usual methods of preparing ammonia on a commercial scale. Write the equation.

5. Describe an experiment illustrating the bleaching properties of SO_2 . Explain.

6. Distinguish between (a) allotropism and isomerism; (b) efflorescence and deliquescence; (c) hard and soft water.

7. Mention three distinct allotropic forms of carbon. Compare the physical properties of the forms mentioned.

8. Describe a method of manufacturing matches. Write two reactions that take place when a common friction match is ignited.

9. Distinguish between (a) a physical change and a chemical change; (b) between a mixture and a chemical compound; (c) illustrate each.

10. Mention the constituent metals of these alloys: bell metal, pewter, brass, soft solder, German silver, type metal, Babbitt metal.

11. Write the chemical name of each: white lead, blue vitriol, calomel, gypsum, caustic potash, copperas.

12. Describe a method of preparing phosphorus and write the reactions.

13. Find the weight of the products of combustion when 26 g. of alcohol (C_2H_6O) are burned.

14. Write the graphic formula of hydrogen arsenide and the reaction for its complete combustion.

15. Describe an experiment to show that a metal changes in weight when heated in air. Explain.

16. What is a solution? Describe an experiment to illustrate (a) a saturated solution; (b) a supersaturated solution.

17. Describe a method of preparing nitrogen and make a sketch of the apparatus. Give the important physical and chemical properties of N.

18. Give the important physical and chemical properties of bromine. Mention one source and two uses of bromine.

19. Describe a test to show the presence of each of the following: oxygen, iodine, sodium, carbon dioxide, lead.

20. A liter of gas under standard conditions weighs 2.0608 g. Find (a) its vapor density; (b) its molecular weight.

21. Name four important constituents of the air and give the relation of each to plant and animal life.

22. Describe the preparation of nitrous oxide, writing the reaction, and give the important properties.

23. Describe the process by which the pig iron of commerce is obtained from the ore by means of a blast furnace.

24. Name the four most important constituents of ordinary illuminating gas. Give the relative importance of these constituents in the production of (a) light; (b) heat.

25. Describe the Bessemer process of manufacturing steel and make a tabular statement of the physical and chemical difference between wrought iron and cast iron.

26. What substance did you employ in the laboratory preparation of hydrochloric acid? Why was each substance selected?

27. Describe the action and explain what occurs when chlorine water is added to a solution of potassium iodide containing starch.

28. Give three methods for collecting gases and state the conditions under which each may be advantageously employed.

29. How many cubic centimeters of H_2SO_4 , containing 49 g. per liter, will be required to neutralize 2 g. of sodium hydroxide?

30. Describe the preparation of hydrogen gas and make a sketch of the apparatus used. How can it be proved experimentally that water is formed when H burns?

31. (a) How is coal gas manufactured? (b) How could you show by experiment that particles of solid carbon are present in a luminous flame of coal gas? (c) Why is a Bunsen flame nonluminous?

32. Describe the process by which metallic aluminum is manufactured. Describe the reaction that takes place between metallic aluminum and ferric oxide when a mixture of the two is ignited. What practical applications are made of this reaction?

33. What is meant by the term "catalysis"? Name three processes or reactions where a catalytic agent is present.

34. Describe the essential features of the mechanical filtration process for the purification of large water supplies.

35. What occurs when a solution of copper sulphate is electrolyzed (*a*) with both electrodes of platinum? (*b*) with both electrodes of copper? Describe the electrolytic purification of crude copper.

36. Define basic anhydride and acid anhydride; give an example of each. What is a dibasic acid? Give examples.

37. Describe in detail the Le Blanc process for the manufacture of soda.

38. Discuss the periodic classification of the elements.

39. Explain briefly two practical methods of determining the combining weights of oxygen and hydrogen.

40. How may lime be shown to be the oxide of a metal?

41. How may sulphuretted hydrogen be made? Give the properties and uses of this substance.

42. What is soap? How is it made? What is the difference between hard soap and soft soap?

43. Name three substances occurring in nature that are composed of calcium carbonate. What substances are formed when calcium carbonate is highly heated? What change takes place when water is added to the solid product thus formed? What use is made of the latter substance? What chemical change occurs when it is exposed to the air?

44. What is plaster of Paris? What chemical difference is there between the hardening of mortar and the setting of plaster of Paris?

45. State by what experiments you could find out whether or not a compound (*a*) contains water of crystallization; (*b*) is efflorescent; (*c*) gives ions in dissolving; (*d*) is an acid.

46. What experiments should you make to distinguish between (a) magnesium oxide and flour? (b) potassium chloride and potassium bromide?

47. State the practical use and explain the efficiency of the Davy safety lamp.

48. Mention the chemical name and write the formula of each of two oxides of phosphorus, and describe a method of preparing each.

49. Define kindling temperature. Mention, in the order of their kindling points, charcoal, sulphur, coal, phosphorus.

50. Describe, writing the reactions, a method of preparing ammonia by the action of an alkali on an ammonium salt.

51. Define and illustrate filtrate, reagent, triad, halogen, positive element, hydroxide, isomerism.

52. Distinguish in meaning between the following suffixes when used in names of chemical compounds: (a) *ous* and *ic*; (b) *ite* and *ate*; (c) and the prefixes *hypo* and *per*.

53. Find under standard conditions the weight of 1 l. of CO.

54. Define fermentation. Describe a laboratory experiment to illustrate fermentation, writing the reactions.

55. Describe the occurrence of S in nature. Describe the process of extracting sulphur from one of its ores.

56. Describe the manufacture of safety matches and state why they are safer than other matches. Write the chemical reactions that occur when safety matches are ignited.

57. Describe the process of extracting mercury from one of its ores, writing the reaction. Mention the important physical properties and the principal uses of mercury.

58. In what compound does chlorine usually occur in nature (give chemical and common name)? Show by equation how free chlorine is obtained from this body.

59. How is sulphur dioxide made from sulphur and how is sulphuric acid made from it? Write equations.

60. Show by equations how calcium carbonate decomposes on heating and how it reacts with dilute H_2SO_4 . Give the common names of the products of both reactions.

61. Point out the chemical similarity between chlorine, bromine, and iodine. What is this group called? How is each of these elements set free from a salt containing it?

62. Give the Laws of Definite and Multiple Proportion and point out what relation they have to the atomic theory.

63. What is the basis of the Mendeléeff classification? What evidence have we that this is a natural classification? Discuss the properties of the elements in some natural family in such a way as to show their apparent relation.

64. Define the terms "atom," "valence," "equivalent," and "gram-molecule." Explain the following processes: distillation, sublimation, electrolysis, neutralization, reduction, fermentation, precipitation?

65. To what constituents do acids owe their characteristic properties? Does this substance impart these properties to all its compounds? What is the theory advanced to explain the facts embraced in your answer? How do we explain the fact that some acids are stronger than others? Name some other facts which the above-mentioned theory explains.

66. One volume of oxygen at 100°C . will go to form how many volumes of steam under the same conditions? How will the number of molecules of each compare? What inference can be drawn from the last answer as to the character of the oxygen molecule? How do we account for the increase in the density when oxygen is converted into ozone?

67. Give an account of the manufacture of H_2SO_4 . Write the equations. How are the pan acid and concentrated acid obtained from the chamber acid? Give the uses to which this acid is put.

68. Define the terms "acid," "base," and "salt." Discuss the process of neutralization. What is the modern conception as to the condition of acids, bases, and salts in dilute aqueous solutions?

69. Describe the Solway process for the manufacture of soda, giving the reactions.

70. State the Law of Gay-Lussac and the hypothesis of Avogadro, and illustrate each.

71. Give the principal sources and the chemical and physical properties of the following elements: hydrogen, sulphur, nitrogen, carbon, sodium, and zinc.

72. How much metallic iron can be obtained by reducing 23 g. of ferric oxide?

73. If a quantity of steam which, at $100^\circ C.$ and standard pressure, occupies 500 cc. be cooled to $4^\circ C.$, what will be the volume of its resulting water? What will it weigh?

74. Give the properties of sodium, potassium, copper, lead, and phosphorus, and the equations for the preparation of each.

75. Describe the manufacture of white lead, the making of caustic soda, or the refining of copper.

76. Are the reactions reversible by which (a) oxygen is obtained from potassium chlorate? (b) hydrogen from sodium and water? (c) water from oxygen and hydrogen? Why?

77. When dilute acid is poured on zinc, what causes the reaction to go in one direction only? If H dissolved abundantly in water, how far would the reaction go?

78. Is the burning of a candle a reversible reaction that runs to equilibrium? Why?

79. Thin layers of oxides form over the surfaces of most metals, making soldering impossible. The tinsmith makes firm joints by using acid or rosin when soldering. Explain the action.

80. Experiments show that 13.1 g. of zinc unite with 32 g. of oxygen to form zinc oxide. Calculate the combining weight of zinc.

81. Name the following compounds and write the formulas:

1. The magnesium salt of chloric acid.
2. The zinc salt of chlorous acid.
3. The calcium salt of nitrous acid.
4. The potassium salt of hypochlorous acid.
5. The sodium salt of carbonic acid.
6. The lithium salt of perchloric acid.
7. The mercurous salt of nitric acid.
8. The mercurous salt of nitrous acid.
9. The mercuric salt of nitric acid.
10. The compound of sodium and hydrogen.
11. The compound of aluminum and silicon.
12. The two compounds of tin and sulphur.

82. 1 g. of aluminum acted on by acid yields 1230 cc. of H under standard conditions. Calculate the apparent combining weight of Al, and correct this by the use of Dulong and Petit's Law, the specific heat of Al being 0.22.

83. What is a flame? What causes the luminosity of a flame? Why is the Bunsen flame nonluminous? Describe the structure of the Bunsen flame.

84. State Avogadro's hypothesis and illustrate it by means of the union of H and O to form water, and of Cl and H to form HCl.

85. A solution of potassium permanganate undergoes no change when a current of hydrogen gas is caused to bubble through it. It is soon decolorized, however, after treatment with zinc and sulphuric acid. Explain fully the principle underlying these facts.

86. What is ozone? How may it be prepared? What are its properties? What is hydrogen peroxide? What are its properties?

87. What advances of practical importance have resulted from the study of chemistry and from chemical investigation?

88. How is ammonia used in refrigeration? How do you class the radical NH_4 ?

89. Give the formula and properties of acetylene and describe a method by which it may be made.

90. The atomic weight of carbon is 12 and of oxygen 15.9. What is the weight of 1 l. of a gas of the formula C_2H_4 , C_3O_2 , CO , C_2H_2 ? What volume of O will be necessary for the complete combustion of 1 l. of each of these gases? Give equation in each case.

91. Give the equations illustrating the formation of H_2SO_4 from sulphur dioxide, air, steam, and the oxides of nitrogen. State the properties of concentrated sulphuric acid.

92. A piece of calcium chloride becomes moist after prolonged exposure to the air. A clear crystal of sodium sulphate loses its transparency and crumbles to powder after a similar exposure. Explain the principle underlying these facts, and define the terms used to characterize the properties illustrated by them.

93. Calculate the approximate weight in grams of 1 l. of each of the following gases: HCl , Cl_2 , HI , NH_3 .

94. How may CO_2 be prepared? Through what cycle does carbon pass in animal and vegetable life?

95. Define distillation, filtrate, titration, standard solution, catalysis, indicator, polymerization, alkali, neutral reaction, halogen.

96. Explain the term "ion" and "ionization." What classes of substances are ionized when dissolved in water? By what are all such substances designated? Define acid and base in terms of the theory of electrolytic dissociation.

97. Write the equation for preparing hydrofluoric acid and explain the process of etching on glass.

98. Give a brief account of the discovery of any one of the chemical elements, including the name of the discoverer and the approximate date and conditions of discovery.

99. What is the formula for white arsenic? What compound of arsenic is formed when a solution of the substance is brought together with zinc and sulphuric acid? Why is the compound not formed when hydrogen gas is led through the solution?

100. In what great industry is calcium phosphate (normal) employed? To what treatment must it first be subjected?

101. Name an important ore of lead. Describe a method of extracting lead from the ore mentioned, and mention two practical uses of lead.

102. Give a brief account of the alkaline-earth metals. Tell how glass is made and colored.

103. State the general difference between metals and non-metals. What is a heavy metal?

104. Is the process of oxidation accompanied by the process of reduction? Illustrate by an equation and interpret. Is occlusion a chemical or a physical action? State your reasons.

105. A gas globe when full of air weighed 55.06 g., and when full of water at 20° C. it weighed 309.66 g. The air

was removed from the globe and the latter carefully weighed by means of a counterpoise. The globe was then filled with a gas at 19.8°C . and 761.4 mm., when it weighed .469 g. more than when the air was exhausted. What is the weight of a liter of this gas under standard conditions?

106. How many cubic centimeters of water will have to be added to 10 g. of H_2SO_4 to yield a 10 per cent solution of the acid?

107. What is the heat of formation of sulphuric acid from its elements in a dilute aqueous solution?

108. Calculate the percentage composition of garnet ($\text{Ca}_3\text{Fe}_2 \cdots (\text{SiO}_4)_2$); of mica ($\text{KH}_2\text{Al}_3(\text{SiO}_4)_3$).

109. How much does a mole of sulphuric acid weigh? of sodium chloride? of ammonium nitrate?

110. A compound of hydrogen and carbon of exactly the same percentage composition has the gas density of 39. What is its formula?

111. In the preparation of phosphine what gases may take the place of hydrogen?

112. What is a mineral? Are the following substances minerals: quartz, water, granite, mercury, soil, coal oil?

113. What other elements besides aluminum act either as acid formers or as base formers?

114. What substances must be avoided when galvanized-iron vessels are in use?

115. Why is nitric acid a better solvent for Hg, Cu, and Ag than hydrochloric or sulphuric acid?

116. A silver dollar contains 10 per cent alloy and weighs 26.5 g. How much is the silver in it worth? How could you separate it from the copper?

117. Prove that the phosphorus molecule has 4 atoms.

118. Reduce the following to the Fahrenheit scale:
(a) $+35^{\circ}\text{C.}$; (b) $+89^{\circ}\text{C.}$; (c) -40°C. ; (d) -50°C. ;
(e) $+104^{\circ}\text{C.}$

119. Reduce the following to the centigrade scale:
(a) 38°F. ; (b) 120°F. ; (c) -64°F. ; (d) -30°F. ; (e) 0°F. ;
(f) -40°F.

120. Outline the contact and the lead-chamber processes of manufacturing H_2SO_4 , and compare them as to efficacy.

121. Prepare a table of the halogens according to the following form:

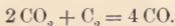
1. Element.
2. Atomic weight.
3. Compounds found in nature (formulas).
4. Equations for the preparation of the element.
5. Physical properties.
6. Chemical properties.
7. Relative replacing power.
8. Equations for the preparation of the hydrogen compound.
9. Stability of the hydrogen compound.

122. What are the speeds of transpiration of ammonia and nitrogen?

123. Name three substances — one gas, one liquid, and one solid — that are used for disinfecting and that have bleaching properties. Explain the action of each in bleaching. State the advantage of formaldehyde for fumigation.

124. In what liquid is sodium usually kept? How are red and yellow phosphorus usually kept? Explain.

125. Give Avogadro's Law and find how many cubic feet of CO are represented in the following reaction if there are represented 10 cu. ft. of CO_2 , all volumes at the same temperature and pressure,



CHAPTER XXVI

PROBLEMS ON MEASUREMENT, TEMPERATURE,
WEIGHT, AND DENSITY

A. MEASUREMENT

1. Find the number of liters in a cubic meter; the number of cubic millimeters.
2. How many millimeters in (a) 16 km.? (b) 21 Hm.? (c) 26.9 m.? (d) 66.92 dm.? (e) 108.2 cm.?
3. How many feet in 62.14 m.? in 390 m.?
4. Convert 43 in. into (a) decimeters; (b) hectometers; (c) kilometers; (d) centimeters; (e) millimeters.
5. Calculate the number of liters necessary to fill with water a tank $21 \times 60 \times 8$ ft. in dimension.
6. Required the number of square millimeters, square centimeters, square decimeters, contained in the top of a flat desk measuring 1 m. 20 cm. by 80 cm.
7. How many miles in 15 km.?
8. A room 20 m. \times 50 m. \times 3 m. is filled with air under standard conditions. How many liters are there? How much does it weigh in kilograms?
9. A woodpile containing 1500 m.³ is 12 m. long and 12 m. wide. How high is it?
10. What is the capacity of a tank in liters that is 4 m. \times 9 m. \times 8 m. in dimension?
11. What is the radius in centimeters of a sphere whose volume is measured by 6 l. of water?
12. How deep must a cistern be to hold 8000 l., if the bottom has a radius of 1.75 m.? How deep if it has a square bottom 3 m. on a side?

13. A rectangular scow 40 m. long and 7 m. wide draws 1 m. of water when empty and 3 m. when loaded; find in kilograms the weight of the load.

14. How many liters will a cylindrical gasometer 1 m. across and 15 m. high hold?

15. A pressure of 1000 lb. per square inch is how many kilograms per square millimeter?

B. TEMPERATURE

1. Convert into the centigrade scale:

(a) 36° R.; (b) 28° R.; (c) 76° R.

2. Convert into the Réaumur scale:

(a) 90° C.; (b) 15° C.; (c) 55° C.; (d) 30° C.

3. Convert into the Fahrenheit scale:

(a) 52° R.; (b) 76° R.; (c) 6.7° R.; (d) 25° R.

4. Convert into the Réaumur scale:

(a) 48° F.; (b) 129° F.; (c) 210° F.; (d) -30° F.

5. Convert into the centigrade scale:

(a) 207° F.; (b) 180° F.; (c) 0° F.; (d) -30° F.

6. Convert into the Fahrenheit scale:

(a) 643° C.; (b) 972° C.; (c) -40° C.; (d) 2500° C.

7. Convert into the absolute scale:

(a) 8° C.; (b) 40° C.; (c) 80° C.; (d) 2000° F.; (e) -37° F.

8. Convert into centigrade, Réaumur, and Fahrenheit scales:

(a) 400° and (b) 267° absolute scale.

C. WEIGHT AND DENSITY

1. How much space will 4320 g. of water occupy?

2. What is the weight of water in a tank 20 cm. \times 31 cm. \times 92 cm.?

3. A mass of 63 g. is divided into pills 7 in number. What is the weight of each?

4. If a liter of Hg. weighs 13 kg. 598 g., find the weight in kilograms of 4.2 l.

5. A cubical block of wood 2 cm. on a side weighs 5 g. How far will it sink in alcohol of specific gravity .8?

6. If the density of brass is 8.5, what will be the weight in air of a mass of brass which weighs *in vacuo* 500 g.?

7. A liter flask weighs 25 g. When filled with a mixture of alcohol and water it weighs 867 g. How many cubic centimeters of each in the flask?

8. A piece of cork floats on ether with 12 cc. exposed. What is the entire volume of the cork?

9. The pressure of the air will hold water 30 ft. high in a vacuum. How high will it hold mercury?

10. If a pint of water weighs exactly a pound, how many cubic inches would it contain?

11. A lump of metal weighs a ton. Its weight in water is 1500 lb. What is its specific gravity?

12. Find the mass of 50 cc. of benzine if its density = 0.85.

13. A piece of lead weighed 39.9 g. in air and 36.368 g. in water. What is the specific gravity of lead?

14. Find the volume of 1000 g. of sea water.

15. Find the specific gravity of alcohol from the following data:

1. Weight of specific-gravity bottle empty, 20.3920 g.

2. Weight of specific-gravity bottle filled with water, 70.3412 g.

3. Weight of specific-gravity bottle filled with alcohol, 61.6515 g.

16. A piece of lead weighs 50 g. in air, and when suspended in a liquid whose specific gravity is 1.2 it weighs 44.69. Determine the specific gravity of lead.

17. If sulphuric acid has a specific gravity of 1.84, how many cubic centimeters of it weighs 80 g. ?

18. Nitric acid is 1.52 times as heavy as water. What is the weight of 3 l. of the acid ?

19. A balloon contains 1000 cu. m. of a gas whose density is 0.000092 g. per cubic centimeter. Taking the density of air as 0.0003 g. per cubic centimeter, calculate the total weight which the balloon will lift.

20. A block of wood having a cross section of 5 cm. \times 4 cm. \times 3 cm. floats in water when immersed to a depth of 2.5 cm. What mass of lead on the top would be sufficient to cause complete immersion of the block ?

21. A piece of metal weighs 50 g. in air, and when suspended in a liquid whose specific gravity is 1.2 it weighs 44.6 g. What is its specific gravity and what metal is it ?

22. What is the weight of ammonia and of chlorine necessary to produce 1 l. of nitrogen ?

23. Calculate the specific heat of iron from the following data :

1. Weight of iron used, 100 g.
2. Weight of ice melted, 14.35 g.
3. Temperature of the iron at the beginning of the operation, 100° C.
4. Latent heat of water, 80.

24. How many cubic centimeters of a liquid of specific gravity 1.4 must be mixed with 1 l. of a liquid of specific gravity .8 to make a mixture of specific gravity 1.2 ?

25. A capillary glass tube weighs .2 g. A thread of mercury 12 cm. long is drawn into the tube, when it is found to weigh .7 g. Find the diameter of the capillary tube.

26. Find the length of an iron rod 2 cm. in diameter that weighs 1 kg.

27. If gold were bought in Alaska at a certain price per ounce, and sold in Mexico at the same price, would there be a gain or loss, transportation charges not being considered?

28. A quantity of silver when placed in one pan of an untrue balance appeared to weigh 5 gm., but when placed in the other pan 6 gm. What is the true mass of the silver?



APPENDIX

CHAPTER XXVII

I. PHYSICAL CONSTANTS OF THE IMPORTANT ELEMENTS¹

ELEMENT	SYMBOL	ATOMIC WEIGHTS		VALENCE	SPECIFIC GRAVITY		MELTING POINT	BOILING POINT
		Approximate	Exact		Water	Air		
Aluminum ..	Al	27.	27.1	III	2.6		657.	1500.
Antimony ..	Sb	120.	120.2	III, V	6.6		630.	1500.
Argon	A	40.	39.9			1.38	-188.	-186.
Arsenic	As	75.	75.	III, V	5.7			360.
Barium	Ba	137.	137.4	II	3.8		850.	950.
Bismuth	Bi	208.	208.	III, V	9.7		269.	1435.
Boron	B	11.	11.	III	2.6		infus.	3500.
Bromine	Br	80.	79.96	I	3.1		-7.3	59.
Cadmium	Cd	112.	112.4	II	8.6		322.	778.
Calcium	Ca	40.	40.1	II	1.5		800.	
Carbon	C	12.	12.	IV	1.7-2.1		subl.	3500.
Chlorine	Cl	35.5	35.45	I		2.49	-102.	-33.6
Chromium ..	Cr	52.	52.1	II, III, VI	6.9		1515.	
Cobalt	Co	59.	59.	II	8.7		1530.	
Copper	Cu	63.6	63.6	I, II	8.9		1065.	2100.
Fluorine	F	19.	19.	I		1.31	-223.	-187.
Gold	Au	197.	197.2	I, III	19.3		1065.	
Helium	He	4.	4.			0.13	-271.	-267.
Hydrogen	H	1.	1.008	I		0.07	-256.5	-252.5
Iodine	I	127.	126.9	I	4.9		114.	184.
Iron	Fe	56.	55.9	II, III	7.8		1950.	
Lead	Pb	207.	206.9	II, IV	11.3		327.	1400.
Lithium	Li	7.	7.03	I	0.59		186.	1400.
Magnesium ..	Mg	24.3	24.3	II	1.7		632.	1100.
Manganese ..	Mn	55.	55.	II, IV	7.4		1245.	
Mercury	Hg	200.	200.	I, II	13.6		-38.8	357.
Nickel	Ni	58.7	58.7	II	8.7		1484.	
Nitrogen	N	14.	14.01	III, V		0.96	-210.	-195.
Oxygen	O	16	16.00	II		1.10	-230.	-182.
Phosphorus ..	P	31.	31.	III, V	1.8		44.2	290.
Platinum	Pt	195.	194.8	IV	21.5		1710.	
Potassium ..	K	39.	39.1	I	0.87		62.5	757.
Silicon	Si	28.	28.4	IV	2.0			3500.
Silver	Ag	108.	107.9	I	10.5		961.	2050.
Sodium	Na	23.	23.05	I	0.97		97.6	877.
Strontium ..	Sr	87.	87.6	II	2.5		900.	
Sulphur	S	32.	32.06	II, IV, VI	2.0		114.5	444.6
Tin	Su	119.	119.0	II, IV	7.3		232.	1600.
Zinc	Zn	65.	65.4	II	7.1		419.	918.

¹ This table will be found in the text of Brownlee and others, and is used by their permission.

II. WEIGHTS AND MEASURES

LENGTH

1 millimeter (mm.)	=	0.03937	inch
1 centimeter (cm.)	= 10 mm.	=	0.3937 inch
1 decimeter (dm.)	= 10 cm.	=	3.937 inches
1 meter (m.)	= 10 dm.	=	39.37 inches
1 kilometer (km.)	= 1000 m.	=	0.6214 mile

VOLUME

1 cubic centimeter (ccm.)	=	0.06103	cubic inch
1 cubic decimeter	= 1000 ccm.	=	61.03 cubic inches
1 liter (l.)	= 1000 ccm.	=	1.057 quarts
1 cubic meter	= 1000 l.	=	35.32 cubic feet

WEIGHT

1 milligram (mg.)	=	0.0154	grain
1 gram (g.)	= 1000 mg.	=	15.432 grains
1 kilogram (kilo), kg.	= 1000 g.	=	2.2046 pounds av.

III. TABLE OF METRIC TRANSFORMATION

TO CHANGE	MULTIPLY BY
Inches to centimeters	2.54
Centimeters to inches	0.3937
Cubic inches to cubic centimeters	16.387
Cubic centimeters to cubic inches	0.061
Ounces to grams (avoirdupois)	28.35
Grams to ounces (avoirdupois)	0.0353
Grains to grams	0.0648
Grams to grains	15.43

IV. WEIGHT OF ONE LITER OF VARIOUS GASES
MEASURED UNDER STANDARD
CONDITIONS

Acetylene	1.1614	Hydrochloric acid	1.6275
Air	1.2923	Oxygen	1.430
Ammonia	0.7617	Hydrogen	0.08984
Carbon dioxide	1.9641	Hydrosulphuric acid	1.5211
Carbon monoxide	1.251	Methane	0.7157
Chlorine	3.1650	Nitric oxide	1.3410
Cyanogen	2.322	Nitrogen	1.2501
Ethylene	1.252	Nitrous oxide	1.9677
Hydrazoic acid	1.920	Sulphur dioxide	2.8596
Hydrocyanic acid	1.2036	Steam	0.805

V. PHYSICAL FORMULAS

TEMPERATURE

$$C = \frac{5}{9}(F - 32); F = \frac{9}{5}C + 32; \frac{9}{4}R + 32 = F.$$

BOYLE'S AND CHARLES'S LAWS COMBINED

$$(a) V = \frac{V'(P' - a)}{760^\circ[1 + (.00366t)]}; (b) \frac{V}{V'} = \frac{TP'}{T'P}$$

VI. SPECIFIC GRAVITIES

Alcohol	0.8	Mercury	13.6
Brass	8.4	Nitric acid	1.56
Cork	0.25	Silver	10.5
Coal	1.8	Sulphuric acid	1.84
Gold	19.3	Tin	7.3
Hydrochloric acid	1.22	Water (distilled)	1.
Iron	7.8	Water (sea)	1.025
Kerosene	0.8	Water (ice)	0.92
Lead	11.3	Zinc	7.1

VII. THE PERIODIC CLASSIFICATION OF THE ELEMENTS

SE- RIES	I		II		III		IV		V		VI		VII		VIII	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1		H=1														
2	Li=7		Be=9		B=10.9		C=11.9		N=13.9		O=15.9		F=18.9			
3	Na=22.9		Mg=24		Al=26.9		Si=28.2		P=30.8		S=31.8		Cl=35.2		Fe=55.5 Ni=58.2	
4	K=38.8		Ca=39.8		Se=43.8		Ti=47.8		V=51		Cr=51.7		Mn=54.6		Co=58.5	
5	(Cu=63)		Zn=64.9		Ga=69.5		Ge=71.9		As=74.5		Se=78.6		Br=79.3		Ru=100.9 Rh=102.2	
6	Rb=84.8		Sr=87		Yt=88.3		Zr=89.7		Cb=93		Mo=95.3				Pd=106.2	
7	(Ag=107.1)		Cd=111.5		In=113		Sn=118.1		Sb=119.5		Te=125.2		I=125.9			
8	Cs=131.9		Ba=136.4		La=137.6		Ce=138									
9																
10					Er=164.7		Yb=171.9		Ta=181.5		W=182.6				Os=189.6 Ir=191.7	
11	(Au=195.7)		Hg=198.5		Tl=202.6		Pb=205.4		Bi=206.5							
12			Ra=225				Th=230.8				U=237.8					
	Oxide R ₂ O		Oxide RO		Oxide R ₂ O ₃		Oxide RO ₂ Hydride RH ₄		Oxide R ₂ O ₅ Hydride RH ₃		Oxide RO ₃ Hydride RH ₃		Oxide R ₂ O ₇ Hydride RH			



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